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Insects are disappearing at alarming rates. That could be disastrous for the planet.

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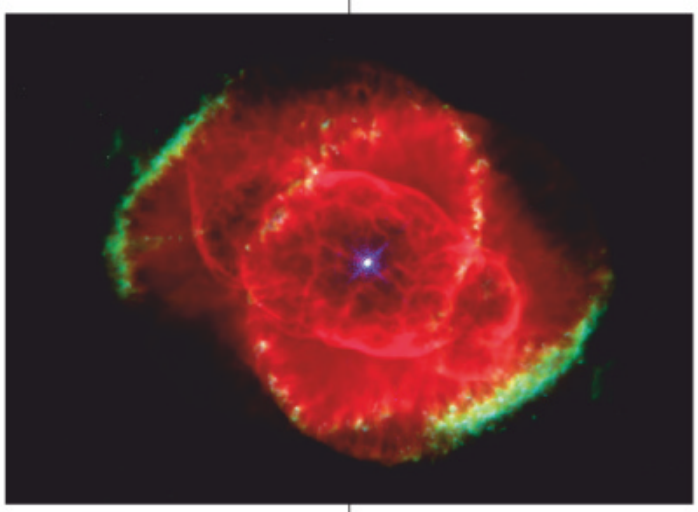
CONTENTS

On the Cover
At the Southwestern Research Station in Arizona, a light trap still lures a multitude of insects. But around the globe, insect populations are shrinking.
DAVID LIITTSCHWAGER

PROOF



8

Hubble's Heavenly Visions
Thirty years after its launch into orbit around the Earth, the optical telescope continues to reveal the secrets of deep space and make amazing images.

EXPLORE

17

THE BIG IDEA

Meet Your Face's Tiny Tenants
The author gets a look at her constant companions: microscopic face mites.
BY ERIKA ENGELHAUPT

THROUGH THE LENS

It's More Than a Show
A photojournalist looks beyond North Korea's propaganda.
BY DAVID GUTTENFELDER

ALSO

Fake Frogs
Disaster Science
Wee Trees

TRAVEL

30

GETTING THERE

Svalbard in Sight
In this remote Arctic region, the focus is squarely on nature's grand displays.
BY DANIEL STONE
PHOTOGRAPH BY ACACIA JOHNSON

CLOSER LOOK

The Exalted Valley
Community-based tourism is helping keep traditions alive along Ethiopia's Omo River.
BY STANLEY STEWART

ALSO

Bird's-Eye Views
Chewable Treasure

IMAGE (HUBBLE): J.P. HARRINGTON AND K.J. BORKOWSKI, UNIVERSITY OF MARYLAND; NASA/ESA

FEATURES

Where Have All the Insects Gone?
Species are vanishing at alarming rates.
BY ELIZABETH KOLBERT
PHOTOGRAPHS BY DAVID LIITTSCHWAGER
..... P. 40

Coming of Age With Autism
Adults on the spectrum find work, love elusive.
BY JUDITH NEWMAN
PHOTOGRAPHS BY LYNN JOHNSON
..... P. 66

Early Autism Signs
With swift detection, effects may be limited.
BY YUDHIJIT BHATTACHARJEE
PHOTOGRAPHS BY LYNN JOHNSON
..... P. 90

A Wild Idea
In Argentina and Chile, millions of acres will be preserved as parkland.
BY DAVID QUAMMEN
PHOTOGRAPHS BY TOMÁS MUNITA
..... P. 94

Bodies in Motion
How animals evolved to move through life.
BY JASON TREAT, BRAD SCRIBER, AND PATRICIA HEALY; ILLUSTRATIONS BY BRYAN CHRISTIE DESIGN
.....P. 118

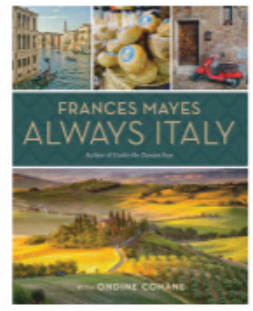
TRAVEL

Italy's Timeless Trails
A migratory tradition lives on in pastoral areas.
BY ALEXIS MARIE ADAMS
PHOTOGRAPHS BY GIUSEPPE NUCCI
..... P. 128

NAT GEO TV

Celebrating 'Queen of Soul' Aretha Franklin

One of the greatest singers of her time and a crusader for civil rights, Aretha Franklin is the focus of the third season of National Geographic's biographical series *Genius*. This first authorized scripted series about Franklin, with Tony Award winner Cynthia Erivo (above) in the title role, will trace Franklin's life from her childhood singing gospel music to her coronation as a music legend. Check local listings for *Genius: Aretha* airtimes on National Geographic.



BOOKS

Savor experts' picks for the best of Italy

More than 350 National Geographic photos bring Frances Mayes's travel hints to life in the lush guide *Always Italy*. Available wherever books are sold.

TELEVISION

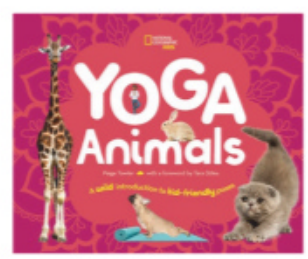
More meals with Gordon Ramsay

The second season of *Gordon Ramsay: Uncharted* follows the renowned chef as he journeys off the beaten path. New episodes air starting Sunday, June 7, at 10/9c on National Geographic.

BOOKS

Mindfulness and yoga for kids

Stretch like a giraffe! *Yoga Animals* guides children step-by-step through easy, animal-inspired poses. Available wherever books are sold.



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ADULTS WITH AUTISM

Love, work, and other challenges

BY **SUSAN GOLDBERG** PHOTOGRAPH BY **LYNN JOHNSON**

Author Judith Newman shares a quiet moment with her son Gus, who is on the autism spectrum; he requests his customary kiss on the head before he leaves for school. Newman chronicled her family's experience of raising a child on the spectrum in her best-selling memoir, *To Siri With Love: A Mother, Her Autistic Son, and the Kindness of Machines.*

"AS GUS AGES into adulthood, the list of his challenges that worry me grows longer," Judith Newman writes of her autistic 18-year-old son. "But the two questions that keep me up at night are: Will he find love, and will he find work that means something to him and allows him to at least partially support himself?"

Love and work. Sigmund Freud considered them the cornerstones of our humanity, and they're the ways most of us come to define our adult lives. Yet as Newman writes in this issue, finding love and work are huge challenges for people with autism spectrum disorder. Some eight in 10 are thought to be under- or unemployed—and about the same number indicate that they'd like a romantic partner. Many don't have one.

Because the number of people with autism is growing, we asked Newman and photographer Lynn Johnson to shine a light on this little-understood condition. And because much has been written about autistic children, we asked them to focus on autistic adults. As Newman puts it, "I think a great deal about what it will take to make my son independent. Some days, it's all I think about. I'm not alone. If there are more than an estimated four million autistic people in the U.S., there are surely a great deal more than four million neurotypical people who love them."

The result of Newman and Johnson's collaboration, "Coming of Age With Autism," is an intimate look at the lives of autistic adults, including Gus. Newman's text is by turns funny and heartbreaking; Johnson's photography invites us to seek a deeper understanding of the people in the images.

We paired Newman and Johnson's story with a report on the latest science around autism, by contributing writer Yudhijit Bhattacharjee. "Since autism was first identified in the 1940s, researchers have struggled to explain it," he writes. "The cause remains a mystery, but scientists are beginning to learn what happens in the brains" of people with autism. There's been progress—but there's a long way to go.

We hope this coverage helps illuminate a complex issue and the lives of people it affects. Too often, we block out those whose behavior we find peculiar or threatening. "We live in fear of people who are socially different," Newman told me. "What are they going to say? What are they going to do?" Here's the question Newman wishes we would consider: "Is it the worst thing in the world that there's a community of adults who will need some help or support…but in many other ways can get along just fine?"

Thank you for reading *National Geographic*. ▯

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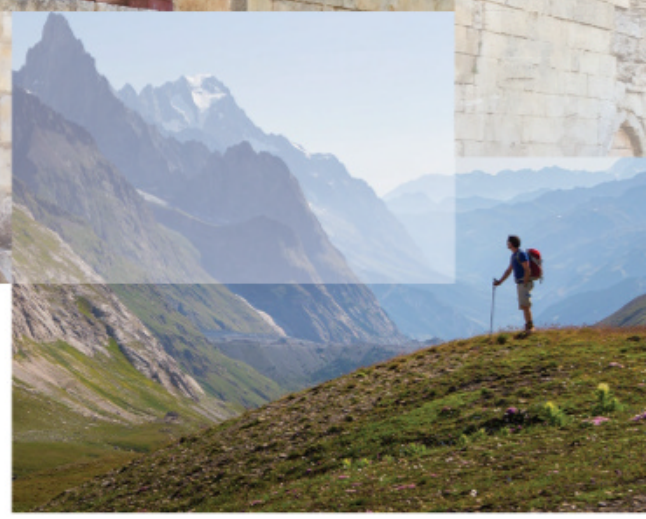

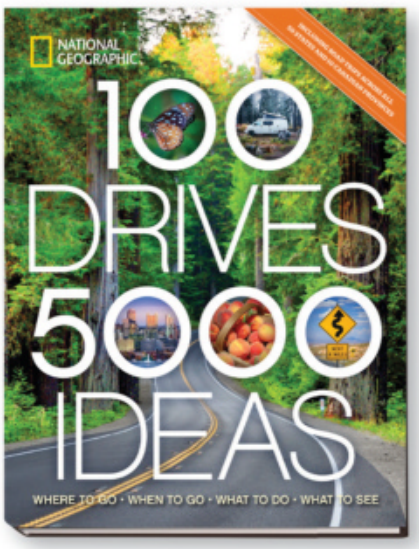

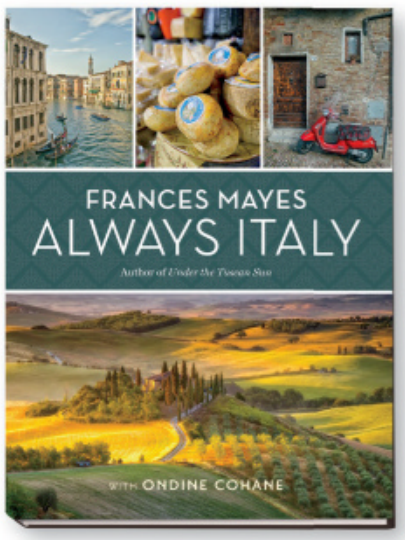

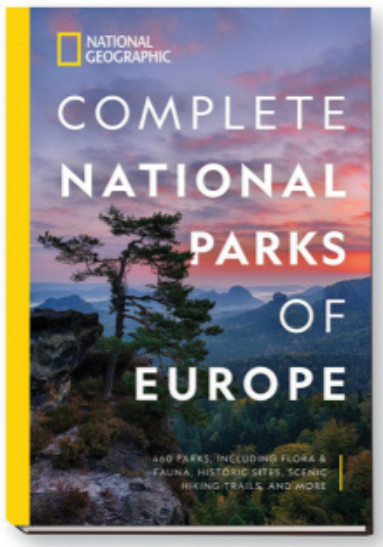
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LOOKING AT LIFE FROM EVERY POSSIBLE ANGLE

NASA/ESA AND Z. LEVAY (STSCI/AURA)

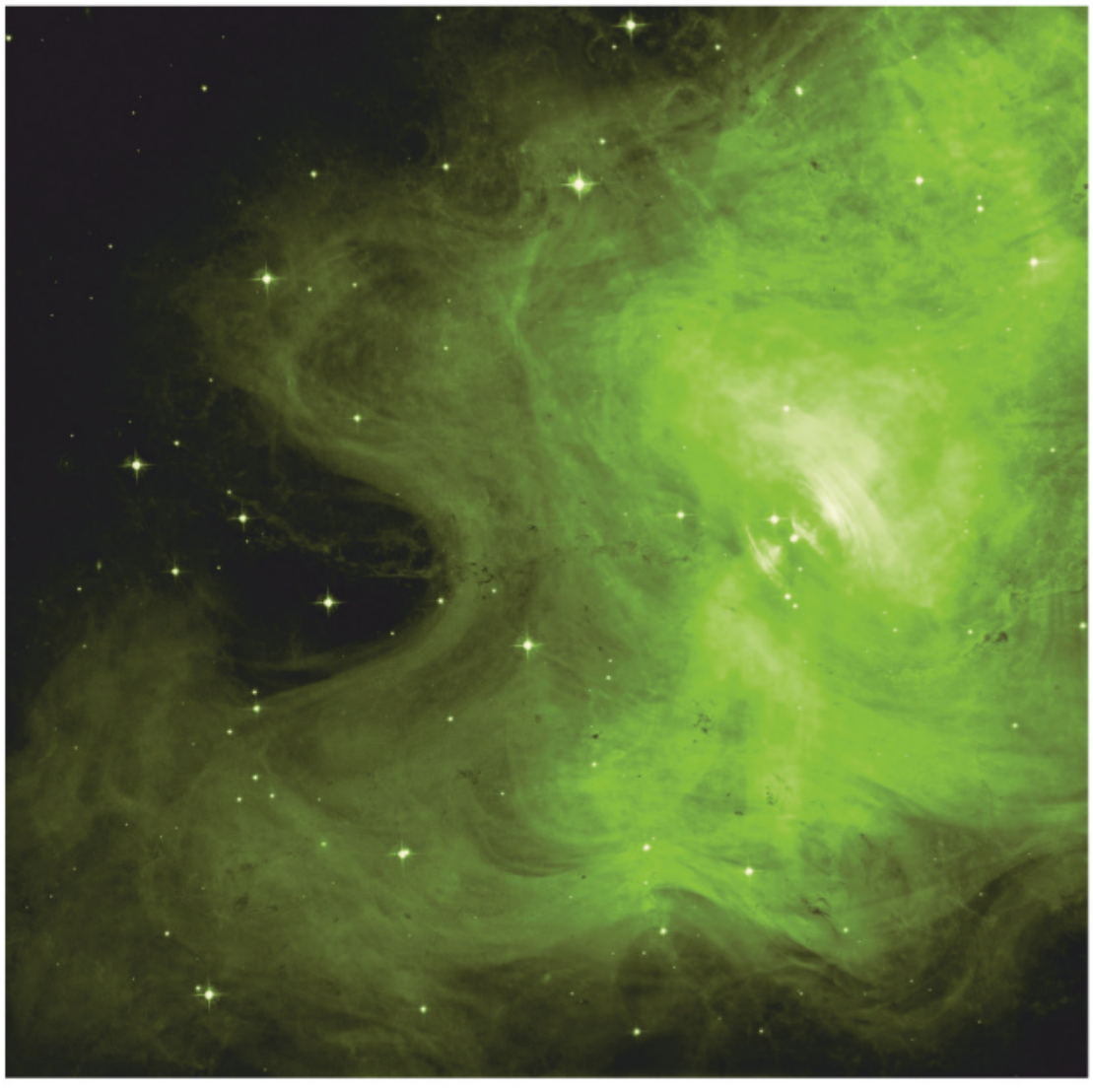
HUBBLE'S HEAVENLY VISIONS

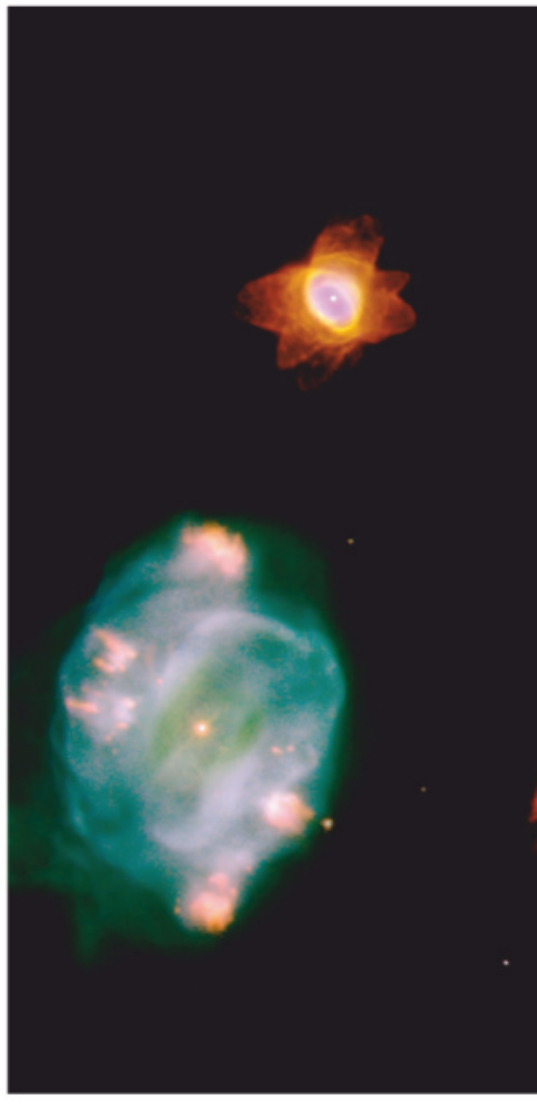
Thirty years after its launch, the telescope continues to reveal the secrets of deep space.

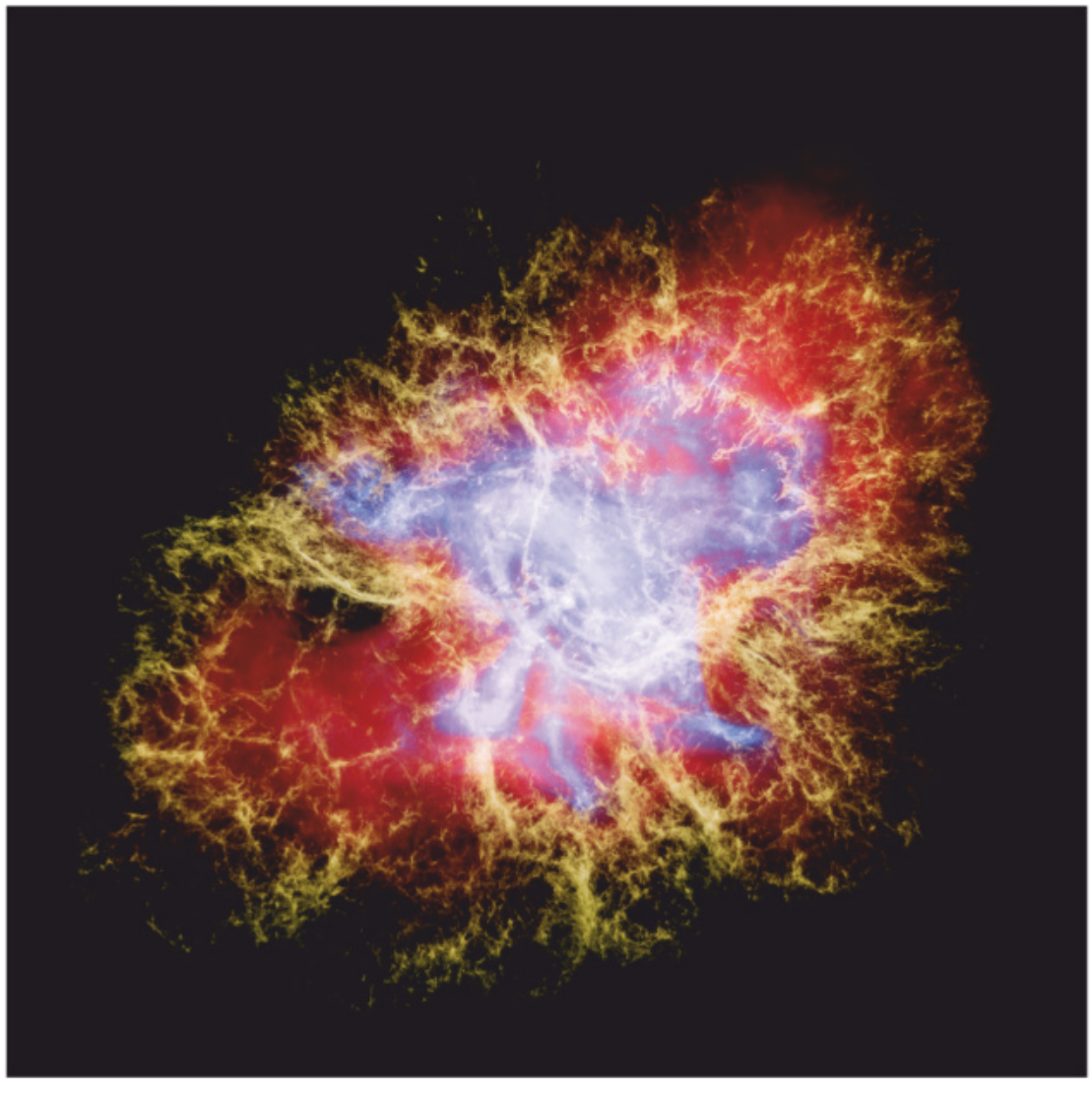
VOL. 237 NO. 5

A colorized composite image captures the Veil Nebula. It's a portion of the doughnut-shaped Cygnus Loop, the result of a supernova explosion several thousand years ago.

PROOF

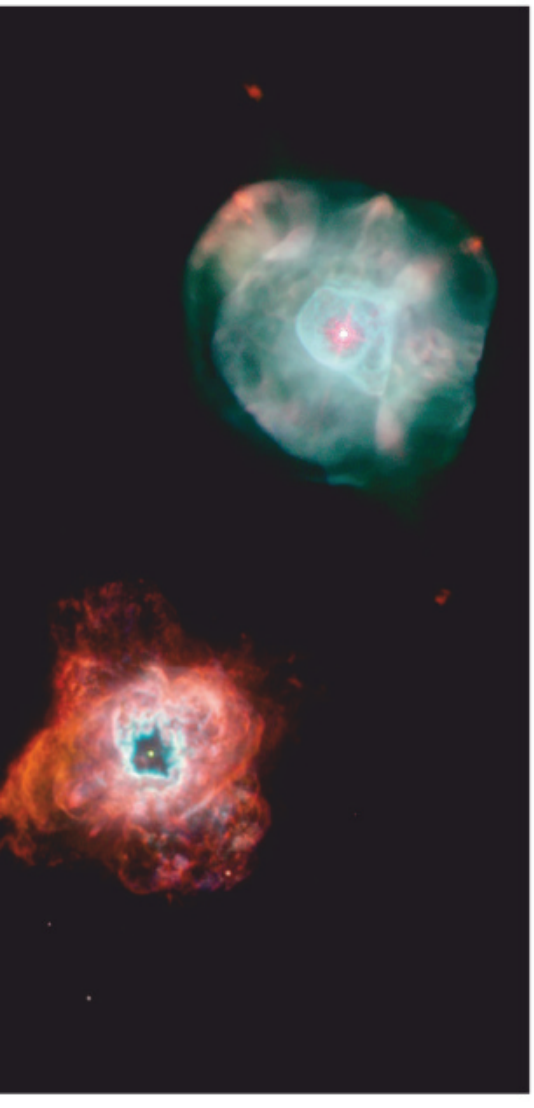


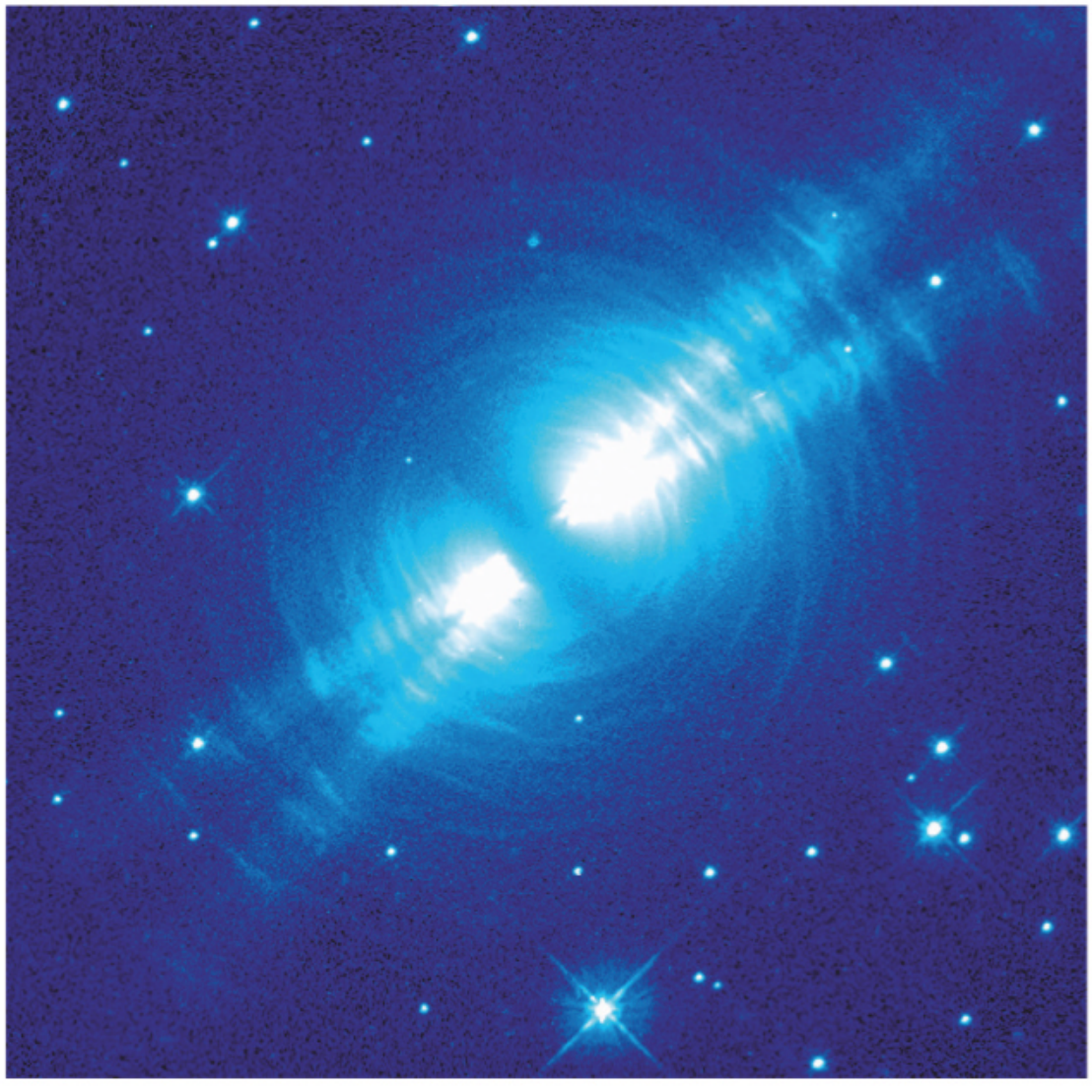




Top row, from left: The Crab Nebula surrounds a superdense neutron star; planetary nebulae emit material expelled from dying stars; the Egg Nebula glows 3,000 light-years away from Earth.

TOP ROW: NASA/ESA (M. WEISSKOPF, NASA MARSHALL SPACE FLIGHT CENTER); NASA/ESA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA); RAGHVENDRA SAHAI AND JOHN TRAUGER. BOTTOM ROW: STSCI; NASA/ESA/STSCI; NASA/ESA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA)





Bottom row: A multi-wavelength view of the Crab Nebula shows the gradient of temperature; the Carina Nebula's gas-and-dust cloud spans three light-years; this faraway group of galaxies is named Arp 273.

PROOF

Astronomers studied 10,000 stars in Hubble pictures to make this composite image and to learn about the evolution of the Milky Way galaxy. Light from our own galaxy is the most recently produced and

NASA/ESA AND T. BROWN, STSCI

most vibrant. Several maintenance missions kept Hubble in shape to capture data that the Space Telescope Science Institute then deciphered and colorized to create stunning celestial images.

THE BACKSTORY

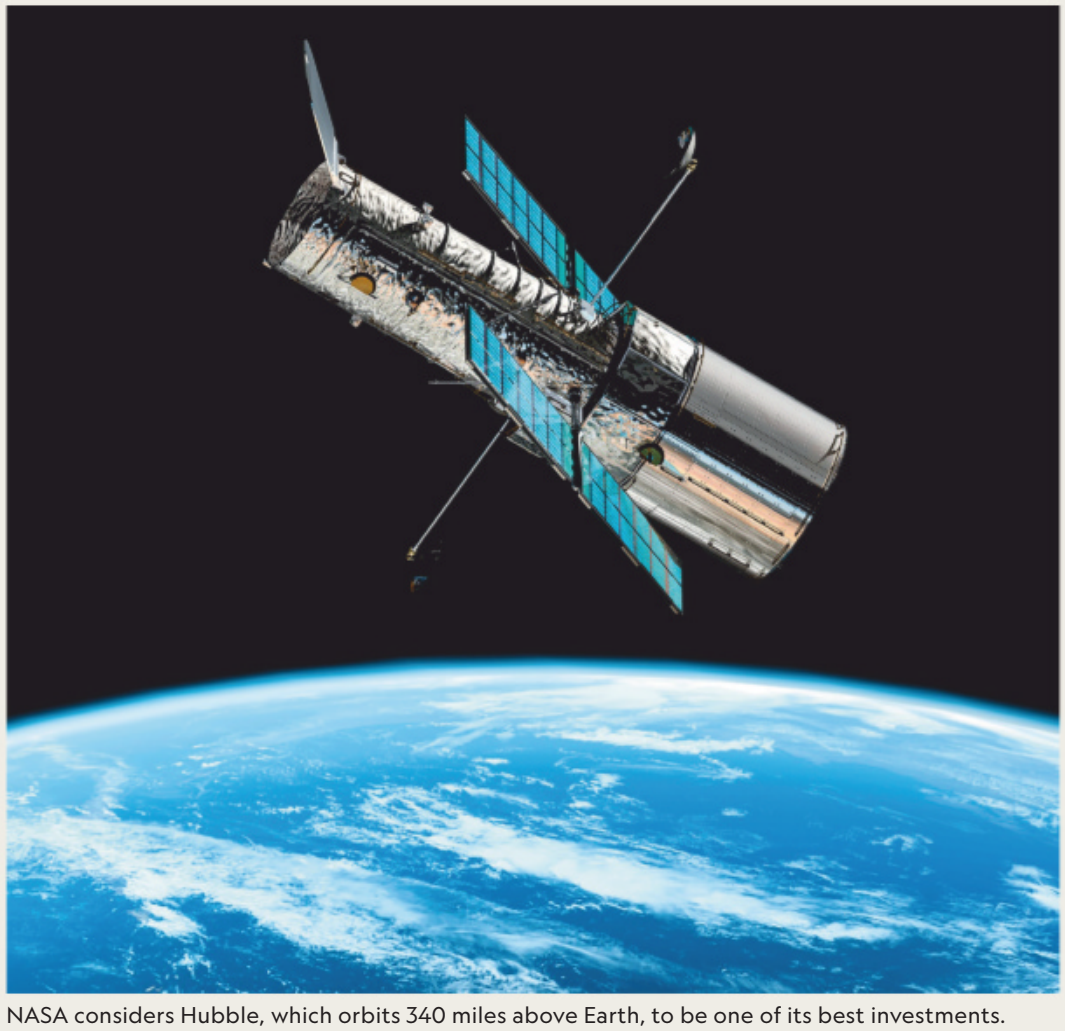
OPERATING FAR BEYOND ITS INTENDED LIFE SPAN, THE HUBBLE TELESCOPE IS STILL SHOWING US DEEP SPACE.

IN 1990 NASA and the European Space Agency launched a telescope designed to peer deep into the universe. Above Earth's atmosphere, the satellite would see without distortions from air, light, and pollution. Scientists said it would last, at best, for a decade.

Thirty years later, Hubble continues to fascinate. Its famous images have helped astronomers answer some of space's biggest questions, from *How old is the universe?* (13.8 billion years old) to *Do black holes actually exist?* (yes, with frightening ferocity). In 1995 astronomer Bob Williams had a zany idea: What if NASA pointed Hubble at a seeming dark spot in the sky? That yielded the magical discovery that even where the human eye sees nothing, thousands of galaxies exist.

"One of Hubble's lasting achievements will be how it showed the public the wonders of the universe," says Kenneth Sembach, director of the Space Telescope Science Institute, which oversees Hubble's science program.

Next year NASA plans to launch the more sensitive James Webb Space Telescope—but Hubble's not done yet. Together, the two will craft an even more complex portrait of the universe and look for answers to a question that never gets old: What else is out there? **—DANIEL STONE**



NASA considers Hubble, which orbits 340 miles above Earth, to be one of its best investments.

ESA

BRANDED CONTENT FOR THE DEPARTMENT OF CULTURE AND TOURISM - ABU DHABI

VISIONS

OF ABU DHABI

THE JUXTAPOSITION OF NATURAL WORLD AND MAN-MADE ENVIRONMENT SETS THE SCENE FOR MEMORABLE ENCOUNTERS IN THE UAE CAPITAL

There's a special kind of silence among the desert sands of the **Empty Quarter**, the 250,000-square-mile expanse that covers much of the Arabian Peninsula. Known locally as the *Rub' al Khali*, this mesmerizing landscape of rolling dunes rises and falls as far as the eye can see, a seething sea of sand almost as big as Texas. Here, where rippling golden grains dance in the sunlight, there is little to disturb the peace, save the occasional snort of a camel or screech of a falcon overhead.

Yet just over 120 miles away, the modern metropolis of Abu Dhabi, capital of the United Arab Emirates, and its surrounding islands including Reem, Yas, and Saadiyat are home to some of the most striking architecture on the planet. Towering skyscrapers reach for the stars, while museums and galleries created by the world's leading architects, such as Jean Nouvel's Louvre Abu Dhabi, house some of the most impressive art collections in the East.

Traditional sailboats (known locally as "dhows") on the calm waters off Abu Dhabi Corniche form a striking contrast against the modern skyline.

Day gives way to night above the endless expanse of the Empty Quarter.

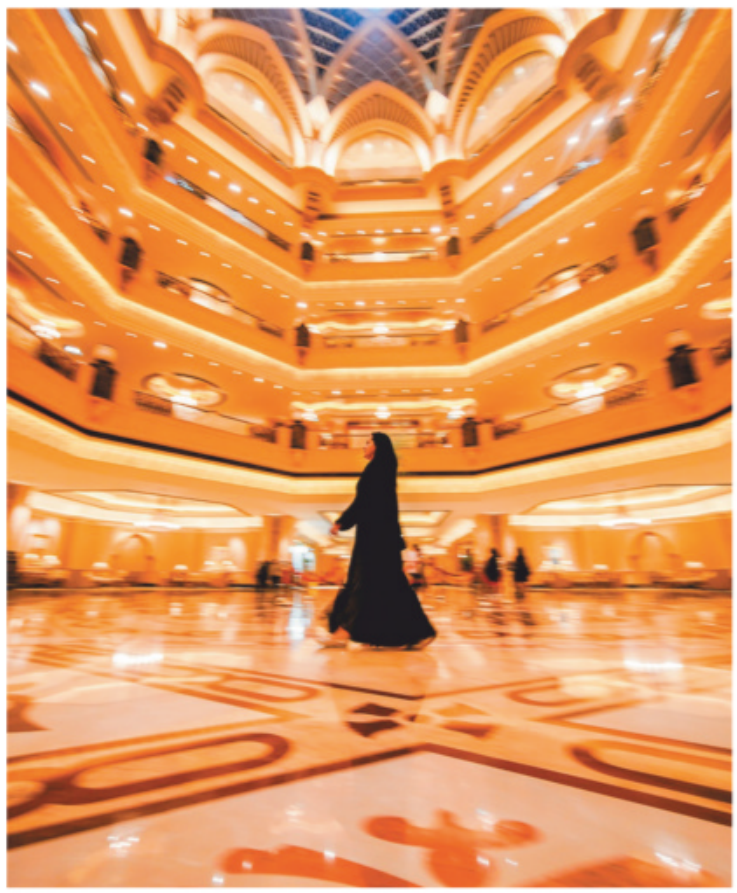
Vibrant, hospitable, and always surprising, Abu Dhabi is a land of contrasts, where diverse themes are united by common values.

The natural world and the man-made environment exist side by side in beautiful symbiosis, as sublime deserts and warm ocean waves encircle the ever-expanding city.

Carved into a series of islands by the waters of the Arabian Gulf, this patchwork of urban endeavor provides a spectacular setting for state-of-the-art theme parks, manicured golf courses, luxury hotels, and gleaming shopping malls. These modern architectural marvels soar above traditional buildings that whisper stories of times gone by. Formidable forts, resplendent mosques, and palaces chronicle the history of this sun-kissed land.

Here, ages-old cultural heritage is preserved and embraced in stylish contemporary settings. Elegant Emirati citizens in traditional attire stroll through malls brimming with international designer brands, while the sound of ancient Arabic music is often heard in beachfront lounges and rooftop shisha cafes at some of the emirate's best hotels.

Visitors to the emirate often note that these paradoxical elements—tradition and modernity; environmental and urban—give Abu Dhabi added depth and character, somehow complementing rather than contradicting each other.



An Emirati lady in traditional attire strolls through Emirates Palace.

This colorful collage never fails to captivate visitors, forming a backdrop for surprising encounters and unexpected experiences; where family fun, active adventures, and luxurious escapes await.

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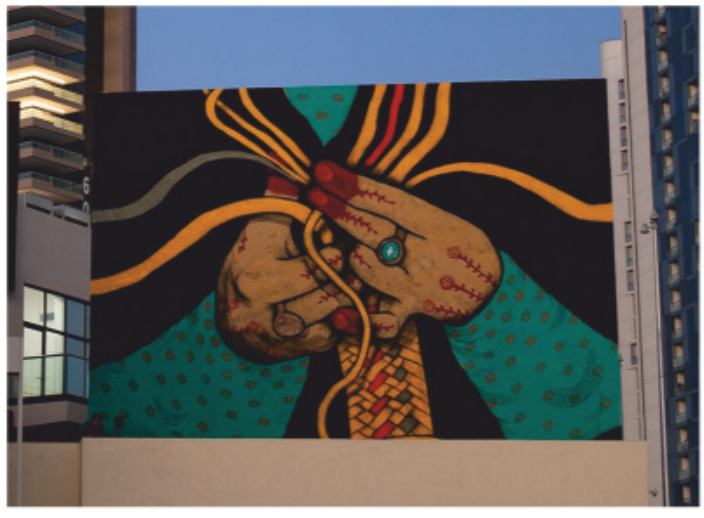
AbuDhabi BY NATIONAL GEOGRAPHIC

SEE MORE. LIVE MORE. LOVE MORE.

National Geographic sent three artists and storytellers to explore Abu Dhabi, each following a different itinerary chosen by our readers. The journeys come to life online, as National Geographic Photographer **Renan Ozturk** and National Geographic Explorers **Paul D. Miller**, aka DJ Spooky, and **Jeremy Collins** each create a piece of art or music inspired by this mesmerizing landscape.

JEBEL HAFIT ULTRA-BRIGHT

Abu Dhabi's spectacular topography inspired artist and photographer **Renan Ozturk** to create a mixed-media, impressionistic painting depicting the craggy landscape surrounding Jebel Hafit, Abu Dhabi's highest peak. The seven-foot unstretched canvas glows with a fiery sunset medley of oranges and yellows rendered in pen, watercolor, and acrylic.



WOVEN

Artist and storyteller **Jeremy Collins** created a 50-foot mural in Abu Dhabi's Reem Central Park portraying an Emirati woman practicing *khous*, a traditional form of palm fiber weaving. Jeremy was inspired by the nimble-fingered women who preserve this ancient craft at the House of Artisans, part of the Al Hosn cultural site that also includes the Qasr Al Hosn fort and the recently reopened Cultural Foundation.

FAJAR DAW: A NEW DAWN

Moved by the contrasts, conversations, and atmosphere he experienced in Abu Dhabi, musician **Paul D. Miller**, aka DJ Spooky, composed a musical portrait that perfectly captures the essence of the destination. Fajar Daw: A New Dawn, was inspired by the sounds of Arabic culture that permeated his journey and the new light of day during the dawn call to prayer.

Follow the colorful adventures of our National Geographic Explorers and Photographer on **nationalgeographic.com/exploremoreabudhabi/** to see breathtaking videos, and beautiful photographs from three incredible journeys.

IN THIS SECTION
Frog alternative
Shampoo sans bottle
The tools of bonsai
Seeing North Korea

ILLUMINATING THE MYSTERIES—AND WONDERS—ALL AROUND US EVERY DAY
NATIONAL GEOGRAPHIC | VOL. 237 NO. 5

Meet Your Face's Tiny Tenants

IN A SAMPLE SCRAPED FROM HER PORES, THE AUTHOR GETS A LOOK AT HER CONSTANT COMPANIONS: MICROSCOPIC FACE MITES.

BY **ERIKA ENGELHAUPT**

AT THIS MOMENT, hundreds or thousands of tiny eight-legged animals are nestled deep in the pores of our faces—my face, your face, your best friend's face, and pretty much every other face you know or love. In some sense, they're our closest companions.

These animals are mites—tiny arachnids, related to spiders and ticks. They're too small to see with the naked eye, and too small to feel as they move about. Not that they move much: Face mites are the ultimate hermits, likely living most of their lives head down inside a single pore. In fact, their bodies are shaped like the inside of a pore, evolution having long ago reduced them to narrow plugs topped with eight absurdly tiny legs.

Face mites were first discovered in the human ear canal in 1841; soon thereafter they were found in the eyebrows and eyelashes. Since then, we've learned that they live not only among towering forests of brows and lashes but also in the savannas of short,

BOTH MITE SPECIES ARE SUCH HOMEBODIES THAT SCIENTISTS HAVE A HARD TIME OBSERVING THEM, EITHER IN CAPTIVITY OR IN THE WILDS OF THE HUMAN FACE. AS A RESULT, WE KNOW LITTLE ABOUT THEIR LIVES.

fine hairs all over our bodies, save the palms and the bottoms of feet. The oil-producing pores in which those hairs sit are particularly dense on the face—as are the mites that live in them.

Perhaps more surprising, our pores are home to at least two different species of mites, both of the genus *Demodex*. The shorter and stubbier of the two is *D. brevis;* it's shaped roughly like the kind of club a cartoon caveman might carry, and it prefers to nestle deeply into sebaceous glands. The other is *D. folliculorum,* which is longer and skinnier and hangs out in hair follicles, closer to the skin's surface.

Both mite species are such homebodies that scientists have a hard time observing them, either in captivity or in the wilds of the human face. As a result, we know little about their lives. Biologists are fairly certain of a few things: Face mites are sensitive to light. They don't have an anus, so they can't poop. And they spend virtually their entire lives on our skin.

Beyond that, we're mostly in the dark about face mites. We assume that they eat dead skin cells and sebum, but no one knows the details of their diet. We know they have sex lives, but the details are murky.

Because these mites are so cryptic, most of us will never see one. But biologist Rob Dunn and colleagues have made breakthroughs in understanding them—so I made it a mission to visit Dunn's laboratory at North Carolina State University in Raleigh. I hoped not only to see my own face mites but also to learn more about these strange beasts. Dunn got interested in studying face mites, he tells me, precisely because they're so mysterious. How could something actually live on our bodies without being noticed?

MEGAN THOEMMES WRAPS her long red hair into a bun and pulls on gloves. Like me, she's steeling herself for what's next: squeezing mites out of my pores. Thoemmes is just finishing her Ph.D. in Dunn's lab, so she's a pro at extracting face mites. But she warns me there's a good chance we won't find any.

A better way to collect *Demodex,* Thoemmes tells me, is to put a drop of cyanoacrylate glue (aka superglue) on a person's face and stick a glass microscope slide to it. When the glue dries, you peel it off (it's not as painful as it sounds, she claims) and the glue pulls everything out of the pores, including the mites, all stuck together in a pore-shaped clump. The lab's record is finding 14 mites in a single pore.

How I learned to love the weird

To me, nothing is more fun than going for a hike and turning over a fallen log to see what slithers out. After all, you never know what you'll see. That's why I love writing about science—it's like turning over an infinite series of logs. While reporting for my new book, *Gory Details,* not only did I get to encounter my own face mites, but I also peeked behind the scenes of a maggot-growing operation and ingested a number of surprisingly delicious insects. I'm drawn to the gross, the creepy, the taboo. (If it's not polite to talk about over dinner, I'm definitely in.) Why? Well, I've found that when I look more closely at whatever rattles me—death, disease, the mites on my face—science makes it a little less scary. It's the reason I've written a whole book of these stories, and why I'm always on the hunt for more. **—EE**

ILLUSTRATION: ARMANDO VEVE

On this morning, Thoemmes couldn't find any superglue, so we're using the old-fashioned method: scraping out sebum with a stainless steel laboratory spatula. I'm nervous that I've driven five hours to see nothing more than a close-up of the gunk in my pores. Thoemmes leans in and scrapes, firmly and steadily. A minute later, she shows me that the spatula holds a healthy smear of translucent face oil; she scrapes it onto a slide, and under the scope it goes.

Thoemmes adjusts the microscope with the deftness of someone who has done it thousands of times. After a few seconds, she mutters, "I think I found one." She looks again. "Yes, I did!" We both squeal with joy. Even better, my mite is alive. I watch its tiny legs wiggle in the bright light.

After we take photos of my prized former face resident, Thoemmes scans the slide looking for more. Slowly, she starts counting. "Two, three … oh, I think I may have found a *brevis*!" She's quiet for a long moment. "Eight mites," she announces—six *D. folliculorum* and two *D. brevis*. That's a lot, Thoemmes tells me diplomatically. She usually finds one or two in a face scraping, if any. I decide to consider myself above average, in a good way.

Thoemmes has one other way to find face mites: using their DNA. When Dunn's group analyzed the DNA in sebum samples, they found face mite DNA in every single person tested over the age of 18 (versus just 14 percent of people via face scraping). In 2014 they published evidence that face mites are ubiquitous in humans. Further DNA research has revealed that face mites have evolved so closely with their human hosts that at least four distinct lineages of mites mirror our own—those with European, Asian, Latin American, and African ancestry.

One of Dunn's colleagues, Michelle Trautwein of the California Academy of Sciences, is continuing to study this diversity. Having sampled mites on people from more than 90 countries, she hopes to sequence the entire face mite genome, opening new avenues of research. We might learn how the mites have evolved alongside us, she says, and a look at their genes could help us understand their physiology despite the difficulty of growing them in the lab.

THE SCIENTISTS WHO discovered *Demodex* living on humans in the 1800s saw them as potential pests or medical problems, and that attitude continued for more than a century. (Because *Demodex* numbers were found to be greater in people with rosacea—a skin condition that produces redness on the face—some dermatologists have assumed that face mites cause the condition.)

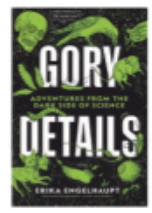
THE SCIENTISTS WHO DISCOVERED *DEMODEX* LIVING ON HUMANS IN THE 1800S SAW THEM AS POTENTIAL PESTS OR MEDICAL PROBLEMS. NOW, THOUGH, OUR VIEW OF FACE MITES IS SHIFTING.

Now, though, our view of face mites is shifting. If virtually everyone has them, either we're all infested or that's not the right word to describe their presence. Even their link to rosacea might not be what it first appeared to be, Thoemmes suggests: What if it's the other way around? Maybe the inflammation and increased blood flow related to rosacea create conditions favorable to face mites. In other words, larger face mite populations could be a symptom of rosacea, not a cause.

What's more, as science has come to view the human body as an ecosystem—home to diverse microscopic flora and fauna—it's not clear that *Demodex* mites should be considered harmful parasites. Mites might even help us, as do the "good" microbes that live in our guts; they could be eating harmful bacteria in our pores, along with dead skin and sebum, or secreting antimicrobial compounds. We and our mites might be in a symbiotic relationship: We feed them pore gunk, they help with the housekeeping.

As for finding my own face inhabited by *Demodex* mites, I feel lucky to have seen them. I hope they're up to something good. And as I wait for science to reveal more about these microscopic squatters, I'm proud to proclaim that I'm mighty mitey. ▯

Science journalist **Erika Engelhaupt** created the blog Gory Details, which can be found at *natgeo.com,* and is author of the new book *Gory Details: Adventures From the Dark Side of Science,* out in May. This essay is an excerpt from the book. It has been edited for length and clarity.



Making mites

Human face mites spend most of their lives in our pores. For scale: Mites' tails protrude from a pore next to an eyelash in this view. Mites emerge at least once in their roughly two-week life span—to reproduce. They likely rendezvous at night near pore and hair follicle openings, scientists say.

PHOTO: STEVE GSCHMEISSNER, SCIENCE SOURCE

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DISPATCHES
FROM THE FRONT LINES
OF SCIENCE
AND INNOVATION

Frog-friendly specimens

There's a new, humane solution to frog dissection. SynFrog is made with synthetic wet tissues that mimic the look, feel, internal organs—and even eggs—of the real thing. It's reusable and it's safe too: Real frogs can be soaked in toxic chemicals such as formaldehyde. –NATASHA DALY

ANIMALS

CANCER GENES BOOST DEER ANTLER GROWTH

DEER TAKE ADVANTAGE OF CANCER'S FAST-DIVIDING CELLS WITHOUT BEING HARMED BY THEM.

RED DEER ANTLERS can grow more than nine inches in a fortnight, reaching a final weight that may surpass 60 pounds. The cells that give rise to these formidable appendages are among the fastest growing in the animal kingdom—and according to a study published recently in the journal *Science,* they engage a variety of genes found in another type of quickly dividing cells: cancer cells. In fact, the genes that these antlers express, or use, are more similar to genes used by osteosarcoma (a type of bone cancer) cells than they are to genes of healthy bone tissue. Yet deer have one-fifth the cancer rate of other mammals, perhaps because deer antler cells also strongly express several cancer-suppressing genes. Understanding how deer put cancer's genetics to good use could help researchers discover oncological treatments in other animal species, including humans. –DOUGLAS MAIN

PLANET OR PLASTIC?

Shampoo breaks free of the bottle

Crush them, add water, and suds up with them in the shower. That's the idea behind the shampoo, conditioner, and body wash that come in tiny cubes, an eco-friendly replacement for travel toiletries in the single-use plastic mini-bottles set to be banned in California hotels starting in 2023. The cube maker, EarthSuds, says that a hotel offering the products for a year could keep 30,000 pounds of plastic out of landfills.
–SARAH GIBBENS

PHOTOS (FROM TOP): SYNDAVER; MARKUS BUERKLE; REBECCA HALE, NGM STAFF

Learn more about plastic waste and take the pledge to reduce it at *natgeo.com/plasticpledge.*

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INNOVATOR

BEVERLY GOODMAN

BY **NINA STROCHLIC** PHOTOGRAPH BY **REBECCA HALE**

She searches underwater to help us survive future emergencies.

When Beverly Goodman was in elementary school, she gave a series of presentations on her favorite topic: disasters. She told her classmates about the eruption that buried Pompeii, the black plague, and famous shipwrecks like the *Titanic* and the *Lusitania*. Today, at 45, she's a marine geoarchaeologist who excavates coastlines for clues to erosion, past tsunamis, and other disasters. "It's funny now that I'm a disaster scientist, basically," she says. "It all came together."

Human settlements have long been built around access to water. Goodman studies how coastal change affected our ancestors: Were people forced to leave? Did they find innovative ways to adapt to the changes? This knowledge, she says, can help us "prepare responsibly for what this landscape is going to look like in the future." That was the case when Goodman and her team of scientists proved tsunamis had struck the coast of what is now Israel over the course of thousands of years. Partly as a result of their research, the country in 2014 developed its first tsunami preparedness plan.

Humans are manipulating coastlines more dramatically than ever, says Goodman. To learn what effect this will have, "we need to be working faster, and we need more people working on it." She believes ancient clues buried underwater can save lives, particularly in places without written records. ▯

Hear Goodman describe the city the tsunami washed away in season two, episode one, of our podcast, *Overheard at National Geographic*.

You May Be Entitled to Replacement Solar Panels and/or a New Inverter from a BP Solar Settlement

Settlement Now Includes BP365TS Integrated Roofing Solar Panels Manufactured Between 2005-2007

Para una notificación en Español, llamar 1-844-360-2767 o visitar nuestro website www.BPSolarSettlement.com

On December 22, 2016, the Court approved a Settlement in a class action lawsuit against BP Solar and Home Depot involving solar panels manufactured between 1999 and 2007 with an S-type junction box ("Class Panels"). You may be entitled to benefits from a $45.33 million common fund or a separate $20 million claims-made settlement. A fee application was filed with the Court on March 4, 2020 and is available for review on the website.

The lawsuit claims these panels are defective and prone to junction box failures, which could cause burn marks at the junction box, shattered glass, and be a potential fire hazard. BP and Home Depot deny these claims.

Who's Included?

The Settlement includes anyone in the United States who: (1) purchased certain BP solar panels for installation on a property, or (2) currently owns a property on which these panels are installed and, in either case, who still owns some or all of the BP solar panels.

The panels were sold through various distributors and retailers, including but not limited to Solar Depot and Home Depot.

What does the Settlement provide?

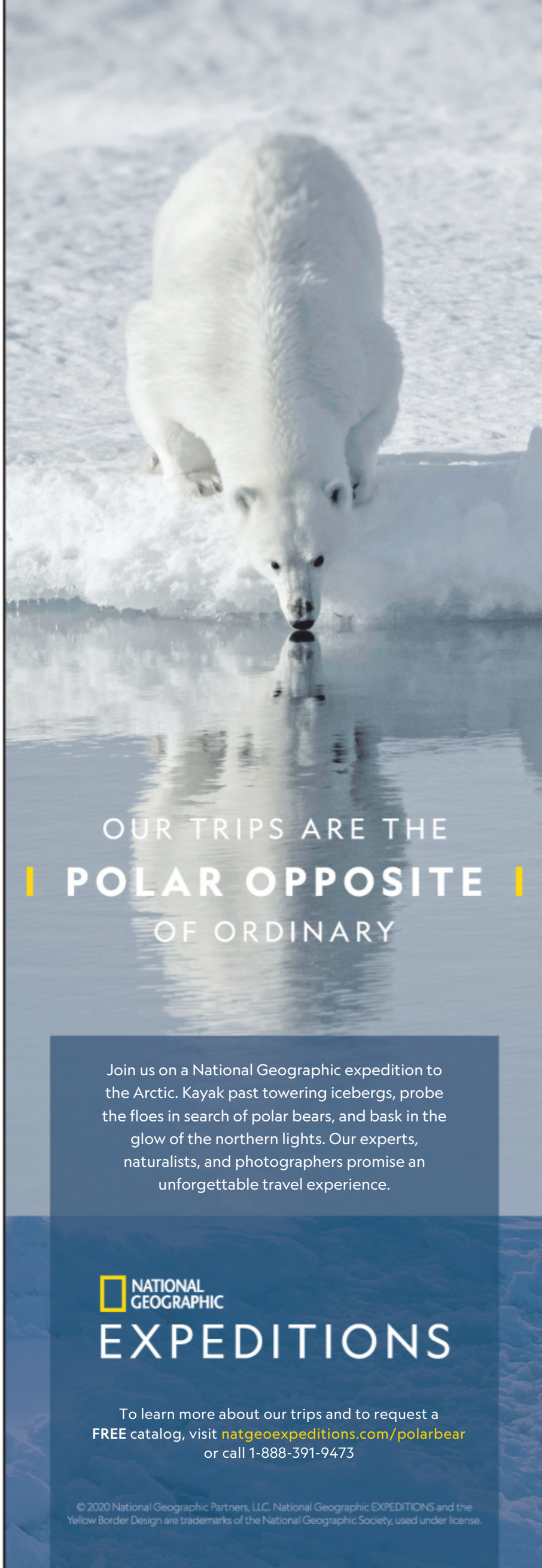
The Court approved a $45.33 million Common Fund to pay for the removal and replacement of a subset of Class Panels (Category 1), and to pay administration, attorneys' fees and costs, and Class Representative awards. The Court also approved the separate $20 million Claims Made Fund for the remaining Class Panels (Category 2), which have a lower failure rate. Category 2 claimants will be entitled to a free visual inspection to identify any failed panels, a replacement of failed panels, and a free inverter with arc fault detection; ***or*** if over 20% of panels have failed, replacement of all panels. Nonresidential class members with 400 or more Class Panels will be invited to commercial negotiations.

How can I receive benefits?

You must file a claim to receive benefits. You can file a claim online at **www.BPSolarSettlement.com** or call **1-844-360-2767**. Category 1 claims will be paid until the Fund is spent, or until such time that the Court decides to terminate the Fund. The deadline to submit Category 2 claims is **July 21, 2020** or until the $20 million fund is spent.

This is only a summary. Complete details about the settlement and the recently added BP365TS Solar Panels are available at **www.BPSolarSettlement.com** or by calling **1-844-360-2767**.

www.BPSolarSettlement.com
1-844-360-2767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TINY TOOLS FOR TINY TREES

PHOTOGRAPH BY **REBECCA HALE**

FOR AMERICA'S BICENTENNIAL in 1976, Japan sent a gift of 53 bonsai trees. Many of them, including one that was first potted in 1625, now reside in Washington, D.C.'s National Bonsai & Penjing Museum. Tending to bonsai requires calm, focus, patience—and a set of miniature tools. "If you don't understand the science to keep them alive, there's no point in understanding the art to make them beautiful," says Michael James, the museum's curator. –NINA STROCHLIC

1. Soil sifters
Soil particles are separated by size to control the oxygen-to-water ratio needed for different tree species.
2. Knob cutters
A concave cutter ensures there's no leftover bump in the wood when a branch is removed.
3. Root rake
When a bonsai is repotted, the dirt is gently raked from the roots.
4. Nylon brush
It's used to clean off moss.
5. Shears
Bonsai must be trimmed regularly to keep the foliage delicate.
6. Tweezers
Trees such as pines are pruned by plucking individual needles. The process can take hours, even days.
7. Soil tamper
After a tree is repotted, the soil is pressed down.
8. Coco brush
This natural-fiber brush cleans up after a pruning.
9. Copper-wire coils
Bonsai must be kept small and shapely. Coils wrapped around branches train them to grow in particular directions.
10. Copper watering can
A long spout helps reach the base of trees with dense foliage.
11. Soil scoops
Volcanic clay from Japan (left), pumice (center), and crushed lava (right) are mixed together to create a porous soil that allows water to drain quickly.
12. Ceramic pot
Bonsai are kept in small containers to restrict growth. This tree, which traces to 1905, was part of Japan's gift to the United States for its bicentennial.

North Korea's Big Show

THE REGIME PUTS ON SPECTACULAR PAGEANTS WITH CASTS OF THOUSANDS. A PHOTOGRAPHER LEARNS TO LOOK BEYOND THEM.

STORY AND PHOTOGRAPH BY
DAVID GUTTENFELDER

EVEN BY NORTH KOREAN STANDARDS, the final event of the country's 70th-anniversary celebration in 2018 was a jaw-dropping spectacle. Many thousands of torch-wielding students marched in waves around Pyongyang's Kim Il Sung Square. The electric flame on top of Juche Tower glowed while the sound of the students' chants and the fireworks' explosions echoed across the immense plaza.

These mass displays have happened often over the 20 years I've spent covering North Korea. I photograph them not only because they're very visual but also because they offer a way to understand the image that the regime wants to project to the world. They present an idealized version of the country—sanitized, curated, united, strong.

North Koreans expect photographers to be purposeful propagandists, not photojournalists with a critical eye. That makes working in North Korea as a foreign photojournalist a challenge. While there, I'm always accompanied by a government-appointed guide whose job is to facilitate my visit and monitor my movements.

On my first trips it seemed that North Koreans expected that a photographer like me, from the adversarial United States, would judge them unfairly, deliberately taking photographs to make them look bad. They closely watched what I was doing. The intense scrutiny led me to be more improvisational with my camera to capture more authentic moments. Often I took photos on the fly, shooting from the hip or from the windows of a bus or car on my way to or from scheduled events. The most interesting pictures—the ones that were candid and real—simply showed regular people doing regular things. And this type of

photography eventually allowed me to open a small window into the everyday lives of North Koreans.

I believe that over time the guides I worked with began to understand what I was trying to do: give a fair and honest look at their country, however unvarnished, however gritty. I was searching for the universal, for everyday life, for real people with real lives worthy of understanding.

Traveling to North Korea as a photographer is even more difficult now than in past years. In 2017 the United States banned travel to the country for U.S. passport holders. When I visited as a journalist to cover the anniversary celebrations a year later, I needed special authorization from the State Department, which issued me a single-use passport to enter. Once I was inside the country for the events, I was confined with other foreign journalists to the area of Pyongyang around the square. Behind me, row upon row of uniformed officers sat on risers. In front of me, the students carried glowing flames and marched.

The images I made during that visit are the kind Westerners have come to expect from North Korea, but to understand the country, we need to get beyond them.

When I look at this photograph now, I think of the people through the years who told me about taking part in these grand shows when they were students—who described the experience as an exciting rite of passage in their lives—and I remember that behind the most extravagant spectacles are ordinary people. □

David Guttenfelder helped open the Associated Press's bureau in Pyongyang, the first Western news office in North Korea. For the April issue, he photographed a U.S. road trip in electric cars.

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LEGAL NOTICE

If You Purchased Trader Joe's Canned Tuna, You May Benefit From A Proposed Class Action Settlement

In re Trader Joe's Tuna Litigation, Case No. 16-cv-01371-ODW-AJW

WHAT IS THIS NOTICE ABOUT? A lawsuit is pending in the United States District Court, Central District of California (the "Action") that may affect your rights. The Action claims that Trader Joe's Company and Trader Joe's East Inc. (collectively, "Trader Joe's") sold underfilled canned tuna in violation of state and federal law. Trader Joe's denies these claims and asserts that the canned tuna was correctly filled and labeled. The Court has not ruled in favor of Plaintiff or Trader Joe's. Instead, the parties agreed to a Proposed Settlement to avoid the expense and risks of continuing the Action. Trader Joe's is settling at the request of the supplier that provides the tuna to Trader Joe's.

AM I A MEMBER OF THE CLASS? The Class is defined as all persons in the United States of America who, from January 5, 2012 through March 2, 2020, purchased one or more cans of (a) 5 oz. Trader Joe's Albacore Tuna in Water Salt Added, (b) 5 oz. Trader Joe's Albacore Tuna in Water Half Salt, (c) 5 oz. Trader Joe's Albacore Tuna in Water No Salt Added, (d) 5 oz. Trader Joe's Albacore Tuna in Olive Oil Salt Added, (e) 5 oz. Trader Joe's Skipjack Tuna in Water With Sea Salt, or (f) 5 oz. Trader Joe's Yellowfin Tuna in Olive Oil Solid Light.

WHAT DOES THE SETTLEMENT PROVIDE? Subject to Court approval, the parties have agreed to a Settlement under which Trader Joe's, on behalf of the canned tuna supplier, will pay $1.3 million in cash. You may submit a claim for a cash payment of $29. The claim amount may be subject to pro rata dilution if the total amount of claims exceeds the available settlement funds.

WHAT ARE MY RIGHTS? You have a choice of whether to stay in the Class or not, and you must decide this now. If you stay in the Class, you will be legally bound by all orders and judgments of the Court, and you won't be able to sue, or continue to sue, Trader Joe's as part of any other lawsuit involving the same claims that are in this Action. This is true even if you do nothing by not submitting a claim.

1. You Can Accept the Settlement. Class Members who wish to receive Settlement Benefits **must** submit claims by **July 1, 2020**. You can get a Claim Form on the Internet at http://www.tjtunasettlement.com. Read the instructions carefully, fill out the form, and submit it online on or before **July 1, 2020**. Alternatively, you may also submit a Claim Form by mailing it to the following address: *In re Trader Joe's Tuna Litigation*, c/o KCC Class Action Services, P.O. Box 43502, Providence, RI 02940-3502. It must be postmarked no later than **July 1, 2020**. If you fail to submit a timely Claim Form and do not exclude yourself from the Settlement, then you will be bound by the Settlement but will not receive any Settlement Benefits.

2. You Can Object to the Settlement. If you believe the Settlement is unsatisfactory, you may file a written objection with the Clerk of the Court for the Central District of California and send copies to the following Counsel representing the Class and Trader Joe's:

Plaintiff's Counsel	Trader Joe's Counsel
L. Timothy Fisher	Robert J. Parks
Bursor & Fisher, P.A.	Parks & Solar, LLP
1990 North California Blvd.	501 West Broadway
Suite 940	Suite 1540
Walnut Creek, CA 94596	San Diego, CA 92101

3. You Can "Opt Out" of the Settlement. If you exclude yourself from the Class–which is sometimes called "opting-out" of the Class–you won't get any Settlement Benefits from the Proposed Settlement. You will also be responsible for any attorneys' fees and costs you incur if you choose to pursue your own lawsuit. Such notice shall include your name, current address, signature, and a statement that you want to be excluded from *In re Trader Joe's Tuna Litigation*, Case No. 16-cv-01371-ODW-AJW, postmarked no later than **July 1, 2020**. Send the written notice to: *In re Trader Joe's Tuna Litigation*, c/o KCC Class Action Services, P.O. Box 43502, Providence, RI 02940-3502.

THE FAIRNESS HEARING. On September 14, 2020, at 1:30 p.m., the Court will hold a hearing in the United States District Court for the Central District of California to determine: (1) whether the Proposed Settlement is fair, reasonable, and adequate and should receive final approval; and (2) whether the application for Plaintiff's attorneys' fees of up to one-third of the total $1.3 million settlement fund, plus reimbursement of out-of-pocket expenses, should be granted. Objections to the Proposed Settlement by Class Members will be considered by the Court, but only if such objections are filed in writing with the Court and sent to Plaintiff's and Trader Joe's counsel by July 1, 2020 as explained above. Class Members who support the Proposed Settlement do not need to appear at the hearing or take any other action to indicate their approval. You may hire your own lawyer to appear in Court for you if you wish; however, if you do, you will be responsible for paying that lawyer on your behalf.

HOW CAN I GET MORE INFORMATION? If you have questions or want a detailed notice or other documents about this lawsuit and your rights, visit www.tjtunasettlement.com. You may also contact Class Counsel by email at info@bursor.com, or by writing to: *In re Trader Joe's Tuna Litigation*, c/o KCC Class Action Services, P.O. Box 43502, Providence, RI 02940-3502.

By order of the United States District Court for the Central District of California.

NATIONAL GEOGRAPHIC | VOL. 237 NO. 5

SVALBARD IN SIGHT

ARCTIC PANORAMAS often look flat and desolate, but this Norwegian archipelago features a mountainous landscape with 2,000 miles of coastline. Home to Earth's northernmost year-round settlement, the Svalbard region is populated but not populous—polar bears outnumber people.

WHAT YOU'LL SEE

In this remote terrain, the focus is squarely on nature's grand displays.

- **Light:** During summer months the sun never sets. In winter it never rises, but the northern lights (aurora borealis) dance across the sky.
- **Wildlife:** Reindeer and arctic foxes roam the land, walruses and seals swim offshore, and Atlantic puffins soar overhead. Polar bears can be hard to spot, but that first sighting makes all the effort worthwhile.
- **Landscapes:** Glaciers, fjords, and snow-covered mountains fill the views.

PHOTO TIPS

Be prepared for anything at all times, says photographer Acacia Johnson, because conditions can vary from one moment to the next. To capture both landscapes and wildlife, she advises, bring wide-angle and telephoto lenses; a waterproof camera bag or smartphone case is a must. When composing shots of the scenery, include the horizon line to give a sense of the area's vastness. In spring and fall, Johnson says, pay special attention at sunrise and sunset, when the light illuminates edges of the ice and the ocean looks like a glowing mosaic.

HOW TO GET THERE

Most visitors fly via Oslo to Longyearbyen, Svalbard's largest settlement, which hugs the shore of Spitsbergen island. Because there aren't many reliable roads, exploration is usually done with small ships (fewer than 200 passengers) that can navigate through areas of dense sea ice. Inflatable Zodiacs shuttle travelers onto the tundra and into grottoes for guided hiking and wildlife-watching.

‘IN THE ARCTIC, THE ICE, LANDSCAPES, WEATHER, AND WILDLIFE ARE CONSTANTLY CHANGING—A REMINDER THAT SO IS THE REST OF LIFE.’

—Acacia Johnson

BY THE NUMBERS

60%

APPROXIMATE AREA COVERED BY GLACIERS

650

MILES FROM THE NORTH POLE

3,000

ESTIMATED NUMBER OF POLAR BEARS THAT ROAM THE REGION

BY **DANIEL STONE** PHOTOGRAPH BY **ACACIA JOHNSON**

NGM MAPS

MAY

2

Five bird's-eye views in honor of World Migratory Bird Day, celebrated in the U.S. and Canada on May 9

BY **MARYELLEN KENNEDY DUCKETT**

ODD BIRD

FLYING ISN'T THE FORTE OF THE HOATZIN, A LEAF-EATING BIRD WITH A PENCHANT FOR BELCHING. IT PERCHES ON BRANCHES NEAR WATER IN SOUTH AMERICA—IN PLACES LIKE PERU'S MANÚ NATIONAL PARK.

1

SCULPTURE

Going Sky-High With a Purpose

This spring in Lausanne, Switzerland, a 59-foot-tall bird feeder is promoting the reintroduction of mistletoe into urban settings. Named Park of Eternal Love, the slender structure features a mistletoe ball with berries to attract birds, which then scatter the seeds across the city.

3

NEW BOOK

Behind the Beak

Did you know that crows are able to recognize individual human faces? In *What It's Like to Be a Bird,* artist and naturalist David Allen Sibley delves into the attributes of more than 200 commonly seen species.

4

EXHIBITION

FINE ART TAKES FLIGHT in Chris Maynard's shadow boxes made with ethically sourced feathers. See a display of his work at Childhood's End Gallery in Olympia, Washington, April 24 to May 31.

5

MEGAFLOCK

KENYA'S LAKE BOGORIA LOOKS PRETTY IN PINK FROM THE FLAMINGOS DRAWN TO THE ALGAE-RICH WATER. OTHER BIRDS THAT GATHER HERE INCLUDE AFRICAN SPOONBILLS AND GOLIATH HERONS.

PHOTOS (CLOCKWISE FROM TOP): OSCAR DEWHURST; REBECCA HALE, NGM STAFF; CHRIS MAYNARD, FEATHERFOLIO; MARTIN HARVEY; COMTE/MEUWLY, HUBER.HUBER

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CHEW ON THIS

BY **MARGARITA GOKUN SILVER**

WALK THE MEDIEVAL streets of Pyrgi, Greece, and you'll see women at tables combing through leafy twigs with the concentration of diamond hunters. They're searching for blobs of hardened white goo: mastic, the natural resin prized since antiquity for its aromatic and healing properties. Pyrgi is one of 24 mastic-producing villages, or *mastichochoria,* on the island of Chios.

Although mastic trees are ubiquitous throughout the Mediterranean, the ones renowned for these special qualities grow only on the southern part of Chios. For thousands of years, mastic has been the economic force and source of identity for the island's inhabitants. It was mentioned by Herodotus back in the fifth century B.C., munched by the Romans for teeth cleaning, and exalted by the Ottomans as a spice. People still use mastic today to flavor food and to help relieve aches and indigestion. Researchers are even studying its potential to fight cancer.

Mastic production is a year-round family affair that involves tending the soil, making shallow cuts in the bark from which the mastic seeps, harvesting it, and cleaning it. At the Chios Mastic Museum, visitors get an overview of the process and can stroll through a grove of trees in search of mastic "tears" glistening in the sun. If you want to get a taste of the island's treasure, there's no shortage of ways: Sip it as a bracing liqueur, devour it in desserts, take it as a supplement, or simply chew it au naturel, as the locals have done for centuries.

PHOTO: REBECCA HALE, NGM STAFF. NGM MAPS

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20PGAD05

In the biodiverse Omo River Valley, in the southwest of Ethiopia, a Kara man collects blooms of desert rose.

VALLEY REVIVAL

COMMUNITY-BASED TOURISM IS HELPING TO KEEP TRADITIONS ALIVE IN ETHIOPIA'S OMO RIVER REGION.

BY **STANLEY STEWART**

AT THE END OF A LONG DAY, we walked up to the village of Korcho. Tropical boubou birds were singing their duets on the edge of a lake. Circular huts, made of sticks and crowned with grass roofs, lay scattered along a ridge. Boys were herding cattle toward the family stockades for the night.

Korcho is a village of the Kara people, one of the 16 ethnic groups said to inhabit Ethiopia's Omo-Turkana Basin. Ethiopia may be known for its rich and varied mix of ethnicities, but the diversity in the lower Omo River Valley in the southwest of the country, home to more than 200,000 people, is unparalleled.

One of the cradles of humankind, the valley was declared a World Heritage site by UNESCO in 1980. Ancient stone tools unearthed there "offer evidence of the earliest known technical activities of prehistoric beings," the UNESCO citation reads. The discovery of several hominid fossils has provided vital keys to an understanding of human evolution.

Such has been the isolation of these peoples that until fairly recently few had even heard of the nation of which they were a part. For them, the capital of Addis Ababa might have been another world. To outsiders, the valley appears little compromised by the trappings of modernity.

PHOTO: FAUSTO PODAVINI

HAS THE PRESCRIPTION OPIOID CRISIS AFFECTED YOU OR SOMEONE YOU KNOW? YOU COULD BE COMPENSATED FROM THE PURDUE PHARMA L.P. BANKRUPTCY.

FILE YOUR CLAIM BY JUNE 30, 2020.

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WHAT IS A CLAIM AND WHO CAN FILE?

A "claim" means a right to seek payment or other compensation. You must file a Proof of Claim Form so it is actually received by the deadline. It can be filed by you, by a legal guardian, by survivors, or by relatives of people who have died or are disabled. **All Personal Injury Claimant Proof of Claim Forms and any supporting documentation submitted with those forms will be kept highly confidential and will not be made available to the public.** You do not need an attorney to file a proof of claim for you.

Additionally, partnerships, corporations, joint ventures, trusts, governmental units, and Native American Tribes may also file a proof of claim against Purdue.

Go to **PurduePharmaClaims.com** to find a complete list of instructions on how to file a claim. You will also find a list of the opioids produced, marketed or sold by Purdue.

You may file a Proof of Claim even if a settlement is contemplated in the Purdue bankruptcy so that your claim can be considered as part of any settlement.

WHO DOES THIS AFFECT AND WHAT ARE MY RIGHTS?

If you think you've suffered harm from Purdue or its prescription opioids, you have the right to file a claim even if you may also have received reimbursement from insurance. Examples of claims that may be filed in the Purdue bankruptcy include death, addiction or dependence, lost wages, loss of spousal relationship benefit for things like child-rearing, enjoyment of life, etc., or Neonatal Abstinence Syndrome (sometimes referred to as "**NAS**"), among others.

The deadline to file a claim is June 30, 2020, at 5:00 p.m. Eastern Time. If you do not file a claim by the deadline, you will lose the right to file a claim against Purdue, and you will lose any right to seek payment or compensation you may have had. Proof of Claim Forms, a list of opioids produced, marketed or sold by "Purdue," and instructions for how to file a claim are online at **PurduePharmaClaims.com**. You can also request a claim form by mail, email or phone:

Purdue Pharma Claims Processing Center
c/o Prime Clerk LLC
850 Third Avenue, Ste. 412, Brooklyn, NY 11232
Email: purduepharmainfo@primeclerk.com - Phone: 1.844.217.0912

THIS IS ONLY A SUMMARY OF THE INFORMATION.

Is Purdue out of money? No. For more information concerning Purdue's bankruptcy, Frequently Asked Questions, Proof of Claim Forms, examples of personal injury and other claims that can be filed, instructions on how to file a claim, and important documents including the Bar Date Notice, visit

PurduePharmaClaims.com, or call 1.844.217.0912.

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But inevitably the modern world has edged in. The Ethiopian government is creating a cascade of five dams on the upper Omo, a mighty river that winds for 500 miles through the central highlands and empties on the border with Kenya into Lake Turkana, the world's largest desert lake.

The Gibe III dam in particular, opened in 2015, has already had a profound effect on the hydrology of the lower Omo, disrupting the annual floods that support cultivation and pasturage and undermining a way of life that has flourished here for many centuries. Power lines now stretch across green hillsides flanking the dam reservoir. Some communities are being resettled.

I had come to the Omo from Addis Ababa, driving for three days across the agrarian landscapes of the Ethiopian highlands on roads where most of the traffic was pedestrian. Young men strolled arm in arm while women staggered in their wake beneath heavy sacks. A few horsemen passed. A white-robed priest appeared beneath a splendid parasol.

Ethiopia strains the imagination. The presence of what is believed to be the Ark of the Covenant, housed in an unassuming chapel in the northern town of Aksum, offers a hint of what this world of cloud-high plateaus and plunging gorges, of peaks and blistering salt deserts, of monasteries and castles, would reveal to me.

To ancient Egyptians, Ethiopia was the Land of Punt, a mysterious world where the Nile River flowed from fountains. Medieval Europeans believed it was a place inhabited by unicorns and flying dragons, birthplace of Prester John, keeper of the Fountain of Youth, protector of the Holy Grail, and a supposed descendant of one of the three magi.

Thanks to a remarkably inhospitable geography—Ethiopia is where Africa's Great Rift Valley gets its start—isolation was total. "The Ethiopians slept near a thousand years," wrote historian Edward Gibbon in 1837, "forgetful of the world, by whom they were forgotten."

But increasingly travelers are beginning to find this storied realm. On the third day of my slow-paced journey, somewhere beyond Jimma, fields and villages fell away as we dropped out of the highlands. Views lengthened as the landscape unfolded toward distant escarpments. This was an emptier Africa of savanna and acacia.

Some hours later I was ensconced in the sylvan setting of Lale's Camp, a canvas-tented complex in the shade of wild figs on the east bank of the Omo. A collaboration between local Kara and sustainable travel outfitter Wild Expeditions, the camp is part of a strategy to mitigate the disruptions caused by the dams as well as an attempt to develop a tourism model that extends the economic benefits of travel to host communities.

> SUCH HAS BEEN THE ISOLATION OF THESE PEOPLES THAT UNTIL FAIRLY RECENTLY FEW HAD EVEN HEARD OF THE NATION OF WHICH THEY WERE A PART.

The project provides revenue and employment for the Kara. Funds have been directed toward solar-powered irrigation systems that will allow, in the wake of the disruption of the dams, the continued cultivation of sorghum on the riverbanks, in addition to fruits, vegetables, and herbs that can be sold to the camp kitchens.

Travel from the camp is often by boat, making for less intrusive arrivals in remote communities. One morning we made our way downriver into the channels of the delta. Colobus monkeys quarreled in the forests that lined the banks. Children splashed distressingly close to basking crocodiles. A group of teenage boys peered through the trees.

Some 50 years ago, not far from Lale's Camp, remnants of one of the earliest examples of *Homo sapiens* were found. The area's frequent volcanic eruptions over millennia created layers of debris and soil, which have helped scientists date the hominid and animal fossil fragments preserved in each layer. Almost 200,000 years old, the finds revealed the Omo valley to be one of the first landscapes to be inhabited by our human ancestors.

It is a landscape now changing but ever nurturing, teaching, remembering.

Stanley Stewart's award-winning books explore topics ranging from the sources of the Nile to the steppes of Mongolia. He divides his time between Rome, Italy, and Dorset, England.

Land of origins

Ethiopia—home to some of the earliest humans—was the starting point of National Geographic Fellow Paul Salopek's Out of Eden Walk, a multiyear, 21,000-mile storytelling odyssey tracing humankind's footsteps out of Africa. Follow his journey at *natgeo.com*.

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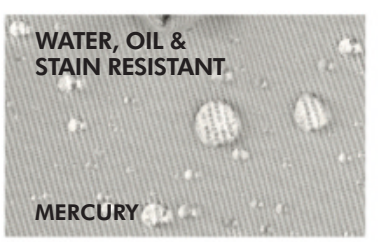

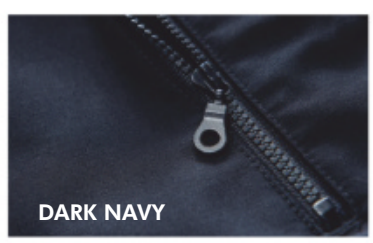

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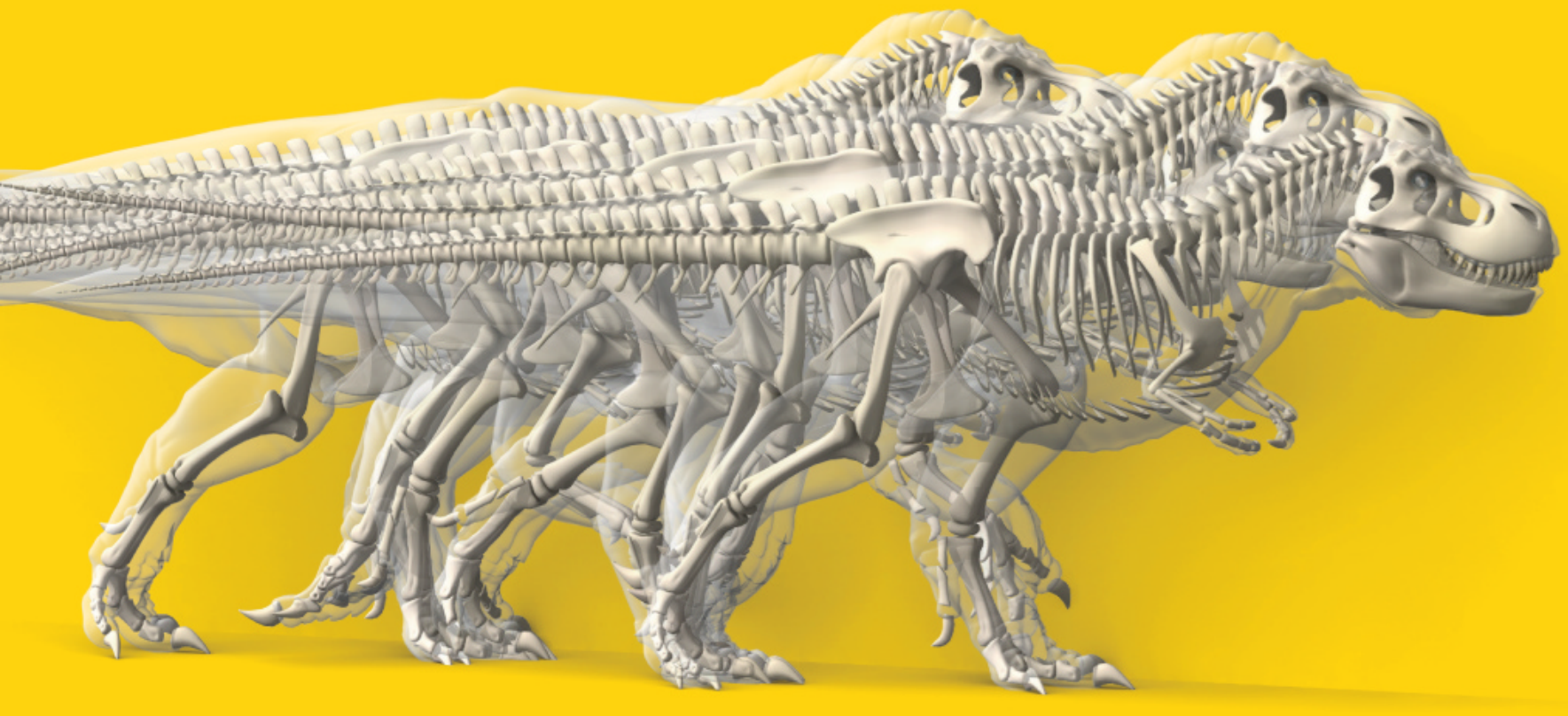
NATIONAL GEOGRAPHIC

MAY 2020

FEATURES

Vanishing Bugs ..... P. 40
Autistic Adults ..... P. 66
Autism Science ..... P. 90
Creating Parks ..... P. 94
Animal Locomotion ... P. 118
Italy's Shepherds ..... P. 128



118

'TYRANNOSAURS MAY HAVE BEEN KINGS, BUT IT'S UNLIKELY THEY COULD RUN FAST. THE LOAD OF THEIR MULTI-TON BODIES WOULD HAVE BROKEN THEIR LEG BONES.'

ILLUSTRATION: BRYAN CHRISTIE DESIGN

BY **ELIZABETH KOLBERT**

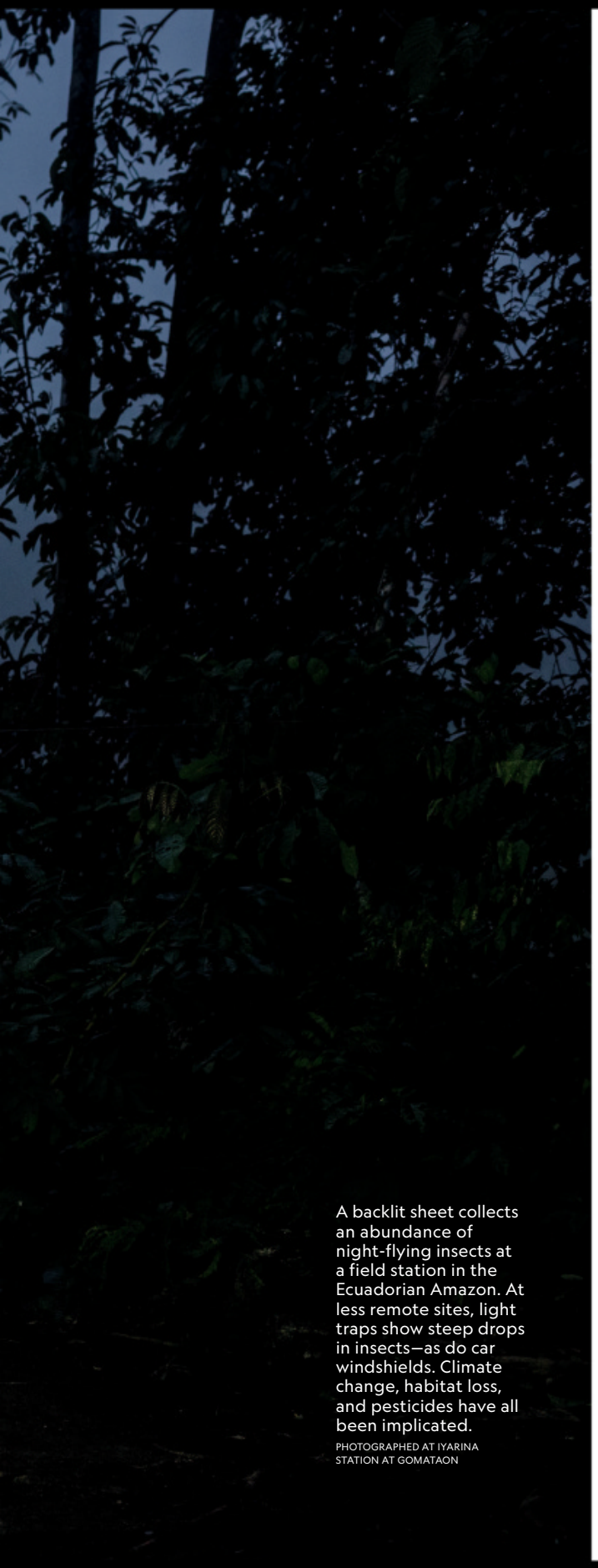
PHOTOGRAPHS BY **DAVID LIITTSCHWAGER**

Where Have All the Insects Gone?

BUGS ARE DISAPPEARING AT ALARMING RATES. THAT COULD BE DISASTROUS FOR THE PLANET.

The extinction of the one-inch-wide Xerces blue butterfly, last seen in the dunes around San Francisco nearly 80 years ago, may have been a harbinger of what some scientists fear could become a global insect die-off.

PRESERVED SPECIMEN PHOTOGRAPHED AT CALIFORNIA ACADEMY OF SCIENCES



A backlit sheet collects an abundance of night-flying insects at a field station in the Ecuadorian Amazon. At less remote sites, light traps show steep drops in insects—as do car windshields. Climate change, habitat loss, and pesticides have all been implicated.

PHOTOGRAPHED AT IYARINA STATION AT GOMATAON

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The wide world of insects: In Arizona, Tennessee, and Ecuador, photographer David Liittschwager made portraits of dozens of bugs in a class (Insecta) that includes millions of species. All, when adults, have six legs, three body segments, and a rigid exoskeleton. Beyond that, diversity rules.

Ten groups are represented here: beetles (Coleoptera); cockroaches and termites (Blattodea); butterflies and moths (Lepidoptera); flies (Diptera); true bugs (Hemiptera); bees, wasps, ants, and sawflies (Hymenoptera); walking sticks (Phasmida); alderflies, dobsonflies, and fish flies (Megaloptera); nerve-wings (Neuroptera); grasshoppers, locusts, and crickets (Orthoptera). The insects shown are identified by genus and species, if known.

1. *Stenelytrana emarginata*
2. *Cryptocercus wright* 3. *Cicindela sexguttata* 4. *Pantherodes unciara* 5. *Asphaera* 6. *Orthosoma brunneum* 7. *Holcocephala* 8. *Choristostigma roseopennalis*
9. *Chrysops* 10. Geometridae (parasitized caterpillar) 11. Reduviidae 12. *Paraponera clavata*
13. *Oreophoetes topoense*
14. Phasmatidae 15. *Megalopyge*
16. *Dryocampa rubicunda*
17. *Dichorda iridaria* 18. *Hypoprepia miniata* 19. *Chauliodes pectinicornis*
20. *Megalodacne heros*
21. *Anotia uhleri* 22. *Megalopyge* (caterpillar) 23. *Telamona*
24. *Arrhenodes minutus* 25. *Cholus*
26. *Compsus* 27. *Compsus*
28. *Euglyphis* 29. Noctuidae
30. Myrmeleontidae (larva) 31. Halictidae: Augochlorini 32. *Acanalonia* (nymph) 33. *Prolimacodes badia* 34. Curculonidae: Conoderinae 35. *Mesothen petosiris*
36. *Heilus* 37. *Laphria* 38. *Neotibicen* 39. Asilinae 40. *Pantographa limata* 41. *Archips purpuana*
42. Hymenoptera: Symphyta (larva)
43. *Palthis angulalis* 44. *Battus philenor* (caterpillar) 45. *Leptoscelis* 46. *Erotylus dilaceratus* 47. *Gibbifer* 48. *Erotylus incomparabilis*
49. *Platyphora* 50. *Erotylus onagga*
51. Chrysomelidae 52. *Symphlebia palmeri* 53. *Laphria* 54. *Epistenia*
55. Ichneumonidae: Ophioninae
56. *Limenitis arthemis* 57. *Amaxia aurata* 58. *Serratitibia* 59. *Pucaya pulchra* 60. *Lophocampa mixta*
61. Syrphidae 62. *Meganola dentata*
63. Reduviidae (nymph)
64. *Oospila* 65. *Cerodirphia*
66. *Charidotis venusta* 67. *Automeris abdominalis* 68. *Lyces fornax*
69. *Pseudautomeris* (caterpillar)
70. *Stolas coalita* 71. Hemiptera: Pentatomidae 72. *Homeomastax dereixi* 73. Geometridae (pupa)
74. (parasitic larva emerged from a Geometridae caterpillar)
75. *Lophocampa* (pupa) 76. Erebidae: Arctiinae (pupa) 77. *Callophrys spinetorum* (caterpillar)
78. *Bertholdia trigona* 79. *Hypercompe permaculata* 80. *Saurita mosca* 81. *Idalus herois* 82. *Acronicta* 83. *Phyllodesma Americana* (caterpillar) 84. Noctuidae: Acontiinae 85. *Gamelia neidhoeferi*
86. *Dysschema dissimulata* (parasitized caterpillar)
87. *Megaceras philoctetes*

What's been lost

Entomologists from Krefeld, Germany, collected flying insects for two weeks in August 1994 (left) and—at the same site, with an identical trap—in August 2016 (this photo). Similar data from 63 German protected areas overall gave a shocking result: a 76 percent drop in insect biomass between 1989 and 2016.

PHOTOGRAPHED AT ENTOMOLOGICAL SOCIETY OF KREFELD

THE BUTTERFLIES JUST KEPT COMING—at first thousands, then tens or even hundreds of thousands. Their wings were brown on the underside and vivid orange above, so as they flew by, they looked like chips of sunshine. The sight was marvelous, awe-inspiring, and more than a little disconcerting.

I encountered the butterfly cloud—technically, an irruption of California tortoiseshells—on a bright blue summer day in the Sierra Nevada. Along with Matt Forister, a biologist from the University of Nevada, Reno, I was hiking Castle Peak, a knob-shaped mountain northwest of Lake Tahoe. Castle Peak's butterflies are one of the world's most closely watched insect populations: Every summer for nearly 45 years they've been censused on a biweekly basis. Most of the data were collected by Forister's mentor, Art Shapiro, a passionate lepidopterist and professor at the University of California, Davis, who recorded the information on three-by-five cards.

After Forister and his team computerized the surveys and analyzed them, they found that Castle Peak's butterflies have been in decline since 2011. We were discussing why this was the case when we neared the 9,100-foot summit and were enveloped in an orange haze.

"The idea that insects are suffering seems shocking to people, which I understand," Forister said. He gestured at the butterflies streaming by: "Insects do this, so it does seem weird."

It's said that we live in the Anthropocene—an

Along the Moselle River in Germany, Martin Sorg, head curator of the Entomological Society of Krefeld, carries a sample bottle from a malaise trap—a tentlike contraption for catching flying insects. Society members have been monitoring such traps since the 1980s.

epoch defined by human impacts on the planet. Still, by many measures, it's bugs that dominate the world. At any given moment, it's been estimated, there are 10 quintillion insects flying, crawling, hovering, marching, burrowing, and swimming around. In terms of variety, the numbers are equally impressive: Something like 80 percent of all the different kinds of animals are insects. They maintain the world as we know it: Without insects to pollinate them, most flowering plants, from daisies to dogwoods, would die out.

If humans were to suddenly disappear, biologist Edward O. Wilson has famously observed, the Earth would "regenerate back to the rich state of equilibrium that existed 10,000 years ago." But "if insects were to vanish, the environment would collapse into chaos."

It is, therefore, shocking—and alarming—that in most places scientists have looked recently, they've found that insect numbers are falling. This is the case in agricultural areas and in wild places like Castle Peak. Quite probably, it's also happening in your own backyard.

THE ENTOMOLOGICAL SOCIETY of Krefeld, Germany, on the Rhine River not far from the Dutch border, stores its collections in a former schoolhouse. Where kids used to fidget through class,

the rooms now hold boxes filled with bottles, and the bottles, in turn, are filled with clumps of dead insects floating in ethanol. If there were a ground zero for the exploding concern about insect decline, the schoolhouse would be it.

"We don't count the bottles, because the number changes every week," Martin Sorg, the head curator of the collection, told me. He estimates that there are "several tens of thousands."

In the late 1980s Sorg and his colleagues set out to find how insects were faring in different types of protected areas in Germany. To get a handle on this, they set up what are known as malaise traps, which look like tilted pup tents. The traps caught everything that flew into them, including flies, wasps, moths, bees, butterflies, and lacewings. Whatever a trap caught ended up in a bottle.

The collecting went on for more than 20 years, first in one spot, then another, in 63 protected areas, mostly in the state of North Rhine-Westphalia, where Krefeld is located. In 2013 the entomologists returned to two sites that they'd first sampled back in 1989. The mass of trapped insects was just a fraction of what it had been 24 years earlier. They sampled those sites again in 2014 and set about resampling more than a dozen other sites. Wherever they collected, the results were similar.

To interpret the results, the society enlisted the help of other entomologists and statisticians, who painstakingly sifted through the data. Their analysis confirmed that from 1989 to 2016, flying insect biomass in protected areas in Germany had declined by a whopping 76 percent.

This finding, published in the scientific journal *PLOS One*, made headlines around the world. The *Guardian* warned of "ecological Armageddon," the *New York Times* of "insect Armageddon." The *Frankfurter Allgemeine Zeitung* declared that "we find ourselves in the middle of a nightmare." According to the website Altmetric, which tracks how often published research is mentioned online, the study was the sixth most discussed scientific paper of 2017. The once obscure Krefeld Entomological Society was deluged with scientific and media requests, and it remains so to this day. "There simply is no end," Sorg said, sighing.

There are multiple species of Andean tiger beetles in the highlands of Ecuador (and more than 350,000 known species of beetles worldwide). This one probably preys on other insects on the forest floor. The orange spots may trick its own predators: They make the beetle resemble a velvet ant wasp, which has a fearsome sting.

PHOTOGRAPHED AT YANAYACU BIOLOGICAL STATION

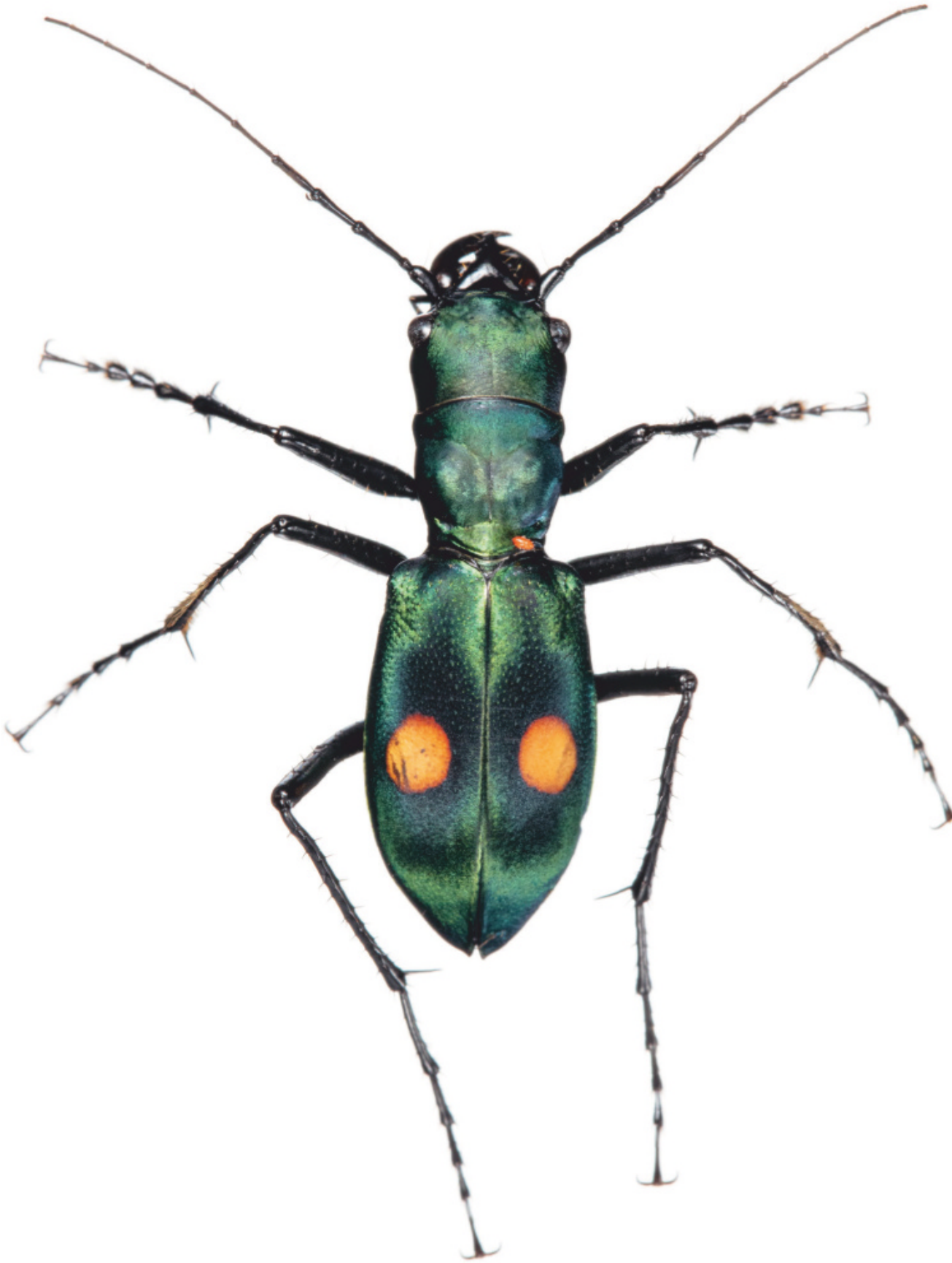
Since the Krefeld paper, entomologists all over the world have been poring over records and collections. Some scientists argue there's a bias in the published papers; they say a study that shows dramatic changes is more likely to be printed than one that doesn't. Still, the results have been sobering. Researchers working in a protected forest in New Hampshire found that the number of beetles there had fallen by more than 80 percent since the mid-1970s, while the bugs' diversity—the number of different kinds—had dropped by nearly 40 percent.

A study of butterflies in the Netherlands found their numbers had declined by almost 85 percent since the end of the 19th century, while a study of mayflies in the upper Midwestern U.S. found their populations had dropped by more than half just since 2012. In Germany a second team of researchers confirmed the gist of the Krefeld results. They found that from 2008 to 2017, the number of insect species in the country's grasslands and forests—sampled repeatedly in hundreds of sites in three widely spaced protected areas—had fallen by more than 30 percent.

"It is frightening," said one of the researchers, Wolfgang Weisser, a professor at the Technical University of Munich. But it "fits the picture presented in a growing number of studies."

PEOPLE MAY DELIGHT in butterflies and detest mosquitoes, but most insects we simply ignore. This says way more about creatures with two legs than it does about creatures with six.

Insects are far and away the most diverse creatures on the planet, so much so that scientists are still struggling to figure out how many different kinds there are. About a million insect species have been named, but it's generally agreed that many more—by recent estimates some four million more—have yet to be discovered. Just one family of parasitoid wasps, the Ichneumonidae,

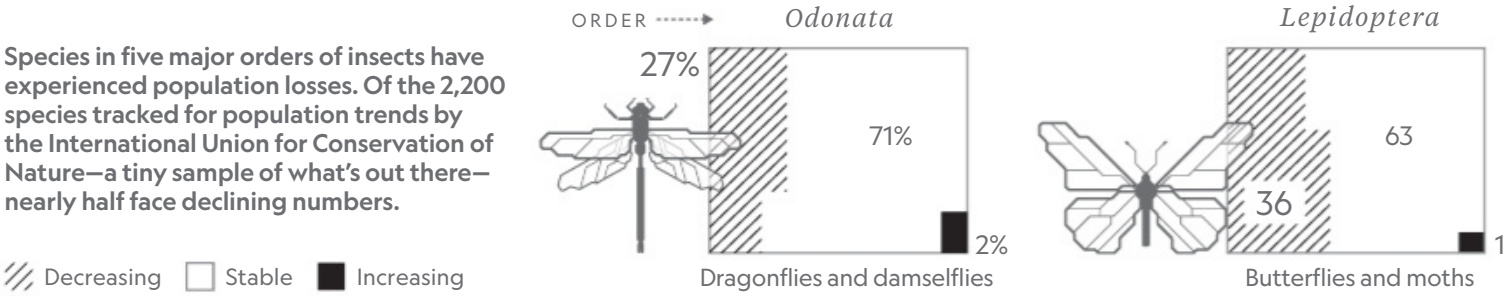


sometimes called Darwin wasps, contains something like 100,000 species, greater than the number of all known species of fish, reptiles, mammals, amphibians, and birds combined. (The mere existence of the Ichneumonidae, Charles Darwin once argued to a friend, was enough to disprove the biblical theory of creation, as no "beneficent and omnipotent God" would have designed such a ghoulish, murderous parasite.) Other insect families are similarly big; there are, for example, perhaps 60,000 species of Curculionidae, commonly known as weevils.

In keeping with their extraordinary variety, insects are found in virtually every type of terrestrial habitat, including the most extreme. Stone flies have been recorded in the Himalaya at elevations above 18,000 feet, and silverfish in caves 3,000 feet below Earth's surface. The Yellowstone hot springs alkali fly lives at the edges of scalding pools, while the wingless midge *Belgica antarctica* survives the cold by coating its eggs in a kind of antifreeze gel. A fly known as the sleeping chironomid, native to semiarid regions in Africa, has larvae that shrink to desiccated flakes in very dry times, entering a kind of suspended animation from which they have been observed to recover after more than 15 years.

What accounts for the tremendous variety of

Species in five major orders of insects have experienced population losses. Of the 2,200 species tracked for population trends by the International Union for Conservation of Nature—a tiny sample of what's out there—nearly half face declining numbers.



Vital and Vanishing

Insects may sting or startle us, but they keep the planet livable. As some insect populations plummet, scientists are scrambling to understand why—is it climate change, pesticides, loss of habitat to farms and cities?—and to identify some of the many unknown species before they're gone.

Eurasian blue tit
(Cyanistes caeruleus)

A pair of blue tits might collect up to 100 caterpillars every day to feed a single chick.

Dung beetles feed on and help decompose the dung of grazers.

Winter moth caterpillar
(Operophtera brumata)

Dung beetle
(Canthon imitator)

INSECTS
NOT TO SCALE

Five crucial insect jobs

Every buzzing, crawling, and hovering insect is a cog in an ecological machine. Tiny, individual efforts add up to colossal benefits for life on Earth.

WHAT COULD HAPPEN IN A WORLD WITHOUT INSECTS:

PROVIDERS

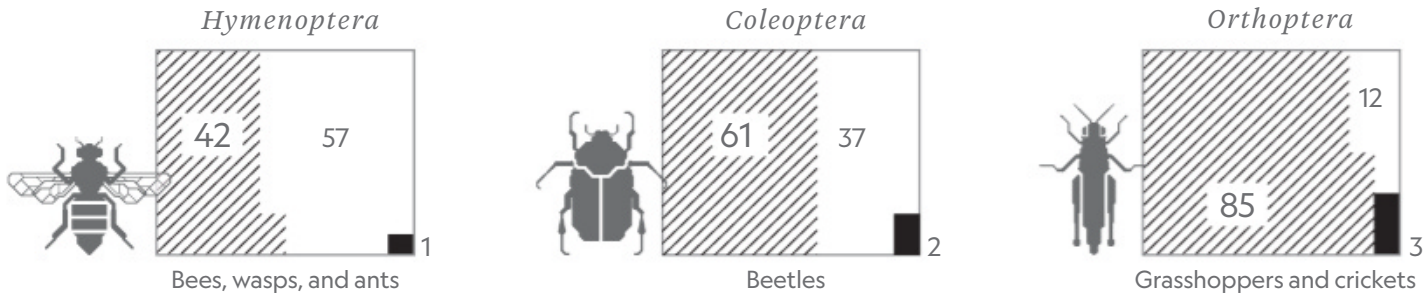
Insects are in nearly every food chain. Many larger animals—birds, bats, amphibians, and fish—eat insects before they in turn are eaten by predators. The dearth of insects is suspected to be a leading cause of recent declines in bird populations.

SPECIES THAT ARE HIGHER UP THE FOOD CHAIN SUFFER POPULATION LOSSES.

DECOMPOSERS

Waste-eating insects unlock nutrients for use by the ecosystem that would otherwise stagnate in dung, dead plants, and carrion. Dung beetles process parasite-breeding and grass-killing cattle dung in 23 months versus the 28 it would otherwise take.

WASTE AND CARRION PERSIST IN ECOSYSTEMS, IMPEDING THE FLOW OF NUTRIENTS.



THE GREAT UNKNOWN

Scientists think that there are nearly a thousand times as many insect species as mammals (of which 5,500 are known) and have identified only one-fifth of them.

5 MILLION

ESTIMATED TOTAL INSECT SPECIES

Rusty patched bumblebee
(Bombus affinis)

A bumblebee can visit (and help pollinate) 3,000 flowers a day.

The damsel bugs in an acre of cropland can eat a million aphids a day.

Damsel bug
(Nabis americoferus)

Aphids
(Acyrthosiphon pisum)

Termites
(Macrotermes natalensis)

One termite colony can excavate a quarter ton of soil every year.

PEST CONTROLLERS

By feeding on crop-threatening pests, predatory insects perform the role of pesticides without chemicals. This cuts pest-control costs and increases yields, saving agricultural industries billions of dollars every year—while reducing toxic pesticide residue on crops.

PESTS PROLIFERATE, DAMAGING CROPS AND FORESTS, SPURRING INCREASED PESTICIDE USE.

POLLINATORS

Nearly 90 percent of flowering plant species and 75 percent of crop plant species depend on pollination by animals—mostly insects. Overall, one out of every three bites of food humans eat relies on animal pollination in the production process.

CROPS CAN'T REPRODUCE; HUMANS AND ANIMALS LOSE KEY FOOD SOURCES.

SOIL ENGINEERS

Termites (and ants) can transform soil in hot, dry climates. Their tunneling aerates hard ground, helping it retain water and adding nutrients. In some regions, the introduction of termites has turned infertile land into cropland within a year.

SOILS IN ARID REGIONS BECOME BARREN, CROPS FAIL, AND DESERTS EXPAND.

MANUEL CANALES, NGM STAFF; SCOTT ELDER. ART: DANIEL SOLANO. SOURCES: SCOTT BLACK AND MATTHEW SHEPHERD, XERCES SOCIETY FOR INVERTEBRATE CONSERVATION. INSECT SPECIES TRENDS: IUCN RED LIST OF THREATENED SPECIES; GRAPHIC ADAPTED FROM RODOLFO DIRZO, *SCIENCE*, 2014. SPECIES NUMBERS: BRETT SCHEFFERS, *TRENDS IN ECOLOGY & EVOLUTION*, 2012

The “zoo” of leaf-filled bags at La Selva Research Station in Costa Rica houses hundreds of caterpillars—and the parasitic wasp eggs inside them. Researchers try to study these species before they vanish. “It’s a desperate science,” ecologist Lee Dyer says.

insects? Many explanations have been offered, the simplest being that insects are old. Very old. They were among the earliest animals to colonize land, more than 400 million years ago—nearly 200 million years before the first dinosaurs appeared. Such an extended history has allowed insect diversity to build up over time.

But having the ability to occupy many different environmental niches probably also mattered. Insects are so small that a single tree can be home to hundreds of kinds, some boring into the bark, others tunneling into the leaves, still others feeding on the roots. This sort of "resource partitioning," as ecologists call it, allows many species of insects to inhabit more or less the same space.

Then there's the fact that insects, historically at least, have had low extinction rates. A few years ago researchers examined the fossil record of the largest suborder of beetles, Polyphaga, a group that includes scarabs, click beetles, and fireflies. They found that not a single family in the group had gone extinct in its entire evolutionary history, even during the mass extinction at the end of the Cretaceous period, 66 million years ago. The finding makes recent declines seem all the more ominous.

EVERY AUTUMN thousands of researchers gather for the annual meeting of the Entomological Society of America. Last fall the meeting was held in St. Louis, and the best attended session was titled "Insect Decline in the Anthropocene."

Speaker after speaker rose to present the doleful evidence. Sorg discussed the work of the Krefeld group, Forister the drop in butterflies in the Sierras. Toke Thomas Høye, a researcher at Denmark's Aarhus University, chronicled a decline in the number of flies visiting flowers in northeast Greenland, and May Berenbaum, an entomologist at the University of Illinois, spoke about the "global pollinator crisis."

David Wagner, an entomologist at the University of Connecticut, had organized the session. When it was his turn at the mic, he pointed to a "conundrum." The speakers, he noted, had all pretty much agreed insects were in trouble, but when it came to a cause, there was no consensus. Some blamed climate change, others farming practices or other infringements on insect habitat. "It's pretty phenomenal that we have so many scientists looking at this problem and yet are not exactly certain what the stressors are," he observed.

A few weeks after the session I met Wagner at the American Museum of Natural History in New York. The museum holds one of the world's most extensive insect collections—row after row of metal cabinets filled with millions of pinned specimens. More or less at random, Wagner unlocked a *Bombus*—or bumblebee—cabinet. In one drawer were Patagonian bumblebees, *Bombus dahlbomii*. Among the largest bees on the planet, they used to be common across much of Chile and Argentina. In recent years their populations have crashed.

Another drawer was filled with rusty patched bumblebees—*Bombus affinis*—which are distinguished by a reddish patch on their backs. Native to the Midwest and northeastern United States, they too used to be common, but their numbers have fallen so low that they're now listed as an endangered species.

"You just can't find them anymore," Wagner said. He explained that there's another species, the gypsy cuckoo bumblebee, that lives by invading the nests of other bumblebees, including the rusty patched, eating their larvae and replacing them with its own. "That bee has also been disappearing," he said.

I asked Wagner what he thought was driving insect declines. On some level, he said, the answer was obvious: "We'd expect things to be declining with seven billion people on the planet." In the process of feeding, clothing, housing, and transporting themselves, people are altering the planet in fundamental ways—mowing down forests, plowing up grasslands, planting monocultures, pouring pollutants into the air. Every one of these is a stressor for insects and other animals. Populations of just about all animal groups are dropping.

"We know we are in a biodiversity crisis," Wagner said.

What is confounding is the rate of insect loss reported in recent studies. Results like those out of Krefeld suggest that insects are declining significantly faster than other animal groups. Why? Pesticides are one possibility; though aimed at "pest" species, the chemicals don't discriminate between insects that damage crops and those that pollinate them. (Even protected areas in Germany may be affected by pesticides, since many of those areas abut agricultural land.) But in some places where steep declines have been reported—the White Mountains of New Hampshire, for example—pesticide use is minimal. Hence the conundrum.

"The issue right now is to figure out to what degree insects are more imperiled than other species," Wagner said. "It's urgent."

"For the first time," he added, "I think people are really worried about ecosystem services and all the things insects do to sustain the planet."

In their nearly infinite variety, insects perform myriad labors, many of them unsung.

On a leaf at La Selva, parasitic wasps in the pupal stage, between larva and adult, cluster on the dying caterpillar that nourished them—and whose population they keep in check. "Declines in parasitic wasps are catastrophic for any terrestrial ecosystem," Dyer says. The site has lost many species of both kinds of organisms.

PHOTOGRAPHED AT LA SELVA RESEARCH STATION

A light trap in Arizona's Chiricahua Mountains is dominated by large white-lined sphinx moths and green stink bugs. Dyer's team has seen no caterpillar decline here. But in years past, he says, this trap captured many more and rarer insects.

PHOTOGRAPHED AT SOUTHWESTERN RESEARCH STATION, AMERICAN MUSEUM OF NATURAL HISTORY

The ebony jewelwing lives along wooded streams in eastern North America; this two-inch specimen is from the Great Smoky Mountains. It eats mosquitoes, among other things, and is eaten by birds and frogs. It's a damselfly, one of nearly 3,000 known species, in the same order as dragonflies. Unlike some relatives, it's not at risk.

PHOTOGRAPHED AT UNIVERSITY OF TENNESSEE BIOLOGY FIELD STATION

Roughly three-quarters of all flowering plants rely on insect pollinators—bees and bumblebees most familiarly, but also butterflies, wasps, and beetles. Most fruit crops, from apples to watermelons, need insect pollinators.

Insects are also critical seed dispersers. Many plants equip their seeds with little appendages, known as elaiosomes, that are packed with fats and other goodies. Ants carry off the seed, eat only the elaiosome, and leave the rest to sprout.

Insects, in turn, provide food for freshwater fish and just about every kind of land animal. Insectivorous reptiles include geckos, anoles, and skinks; tree shrews and anteaters are insectivorous mammals. Birds that subsist mainly on bugs include swallows, warblers, woodpeckers, and wrens.

Even birds that are omnivores as adults often rely on insects when they're young. Carolina chickadees, for example, rear their chicks exclusively on caterpillars. (It takes more than 5,000 caterpillars to fledge a nestful.) A recent study of North American birds found that their numbers also have been in steep decline—down by almost a third since 1970. Species with insect-heavy diets have been among the most hard-hit.

Insects are also crucial decomposers that keep the wheel of life turning. By eating poop, dung beetles help return nutrients to the soil. Termites do the same by consuming wood. Without insects, dead organic matter—including human bodies—would begin to pile up. Under the right conditions, blowfly maggots can consume 60 percent of a human corpse within a week.

It's hard to assign a dollar value to all this work, but back in 2006 a pair of entomologists tried. They looked at four categories of "insect services"—"dung burial, pest control, pollination, and wildlife nutrition"—and came up with a figure of $57 billion a year for the U.S. alone.

LA SELVA RESEARCH STATION is just 35 miles north of Costa Rica's capital city, San José, but getting to it entails a two-hour drive over a steep mountain pass with hairpin turns.

One of La Selva's nightspots used to be a small pavilion equipped with a white sheet and a black light left on to attract insects. So many insects would collect on the sheet that visitors to the station would stay up until dawn to watch them. Over the past two decades, though, the display has become less spectacular, to the point where it's no longer really a display at all. Two trips to the pavilion on steamy nights this past January yielded the following tally: three moths, one weevil, a shield bug, and some gnats.

"When I first came here, this really was a hangout point," Lee Dyer, an ecologist from the University of Nevada, Reno, said of the pavilion. "Now you don't ever see any insects—maybe one or two."

Dyer has been working at La Selva since 1991. His research focuses on the interaction between insects and their host plants, and insects and each other. Many insects live off other insects. Most parasitic wasps, for example, lay their eggs in the bodies of caterpillars, using their hosts as a kind of living pantry: The wasp larvae gradually eat the caterpillars from the inside out. Other insects, known as hyperparasitoids, lay their eggs in or on the bodies of parasitoids. There are even insects that parasitize hyperparasitoids.

With the help of students and volunteers, Dyer has been collecting caterpillars at La Selva and rearing them to see what emerges—moths in some cases, parasitoids in others. Like the members of the Krefeld Entomological Society, he didn't set out to find evidence of insect decline. But it found him. One of his graduate students, Danielle Salcido, recently sifted through the two decades' worth of data. She found that since 1997, caterpillar diversity at La Selva has dropped by almost 40 percent. Parasitoid diversity has dropped by even more—around 55 percent.

Parasitoids help keep many crop-eating caterpillars in check, so if they're declining, agricultural losses may increase. (Salcido found that a couple of groups of caterpillars that are prone to outbreaks were increasing, even as most

caterpillars were declining.) The loss of interactions between caterpillars and parasitoids also means entire food chains may be unraveling, in many cases before humans have had a chance to discover them.

"I was an English major," Dyer said. "And these kinds of interactions, these stories, are like poems." When so many are lost, "it's like burning down a library."

Most long-term data about insects come from the temperate zone—Europe or the U.S. But something like 80 percent of all insect species live in the tropics, which is what makes Dyer and Salcido's findings potentially so significant. Though La Selva is surrounded by agriculture, which brings problems like habitat fragmentation and pesticide use, Dyer believes one of the main drivers of the decline is climate change. In particular he points to the increase in extreme weather events, like floods. Many insect species "are really susceptible, in the tropics especially, to extreme weather conditions," he said. "They're just not adapted to big fluctuations."

Dan Janzen and Winnie Hallwachs are tropical ecologists at the University of Pennsylvania. They spend part of the year in Philadelphia and part north of the city of Liberia, in western Costa Rica, in a house they share with whatever wildlife

On the Tennessee side of the Great Smoky Mountains, UCLA Ph.D. student Graham Montgomery collects insects from foliage, hoping to replicate a survey done 70 years ago. Because long-term data on insect populations are rare, the depth of their decline is unclear. In the past, entomologists didn't often count insects. There were always so many.

settles in, including whip scorpions and nectar bats. When a visitor arrived from La Selva, Hallwachs pointed out a three-inch-long cockroach under the sink. "I tell people, books are nothing but termite food," Janzen said, gesturing toward a small mound of shredded paper in one of the bookcases.

The surrounding landscape is very different from La Selva—tropical dry forest and, up the mountain, cloud forest instead of lowland rainforest. But here too, Janzen and Hallwachs have seen a dramatic decline in insects. Hallwachs recalled that in the mid-1980s, when they got an early personal computer, the light from the screen at night attracted so many bugs they had to erect a tent in the house and work inside it.

"I'm now at a point where every insect that crosses my desk at night goes into a little plastic tube with alcohol," Janzen said. He'd been back in Costa Rica for two weeks and had collected only nine insects.

Janzen and Hallwachs also attribute much of the decline to climate change. Janzen, who's 81, said that when he first started coming to Costa Rica in 1963, the dry season lasted four months. "Today we have a six-month dry season, so all those things that had their lives organized around a four-month dry season are now hit with two extra months. They run out of food, they run out of cues, everything just falls apart."

WHAT CAN BE DONE to reverse these ominous trends? On some level, of course, that depends on what's driving them. If it's primarily climate change, then it would seem that only global action to reduce emissions could really make a difference. If pesticides or habitat loss are the main culprits, then action on a regional or local scale could have a big impact.

In an effort to protect pollinators, the European Union has banned most neonicotinoid pesticides, which several studies have linked to insect and bird declines. Last fall the German government adopted an "action program

for insect protection," which calls for restoring insect habitat, banning the use of insecticides in certain areas, and phasing out glyphosate, a commonly used herbicide. (Glyphosate may be eliminating key plants that insects depend on, and research suggests it also could be disrupting their immune systems.) "We cannot do without insects," the action plan noted.

Recently a group of more than 50 scientists from around the world proposed a "roadmap" for insect conservation. It recommended "taking aggressive steps to reduce greenhouse gas emissions," preserving more natural areas as safe havens for insects, and imposing stricter controls on exotic species. (The collapse of the Patagonian bumblebee, in South America, and possibly of the rusty patched bumblebee, in North America, was caused by bees introduced from Europe.) The group also called for reducing the application of synthetic pesticides and fertilizers.

"There are a lot of things we could do, regardless of how this play ends, that would be good practices," said Wagner, who was part of the group. "Anything to do with climate would be number one on my list. If we could roll back pesticide use for cosmetic purposes, like on our lawns, that's a win-win for the planet."

One of the few organizations in the world specifically devoted to invertebrate conservation is the Xerces Society, based in Portland, Oregon. (The society was named after the Xerces blue, a butterfly native to the San Francisco peninsula that went extinct in the 1940s because of development.) One day not long after I climbed Castle Peak, I went with the society's director, Scott Black, to visit some of its collaborative projects in California's Central Valley. As he drove, Black recalled one of his first loves, a Mustang he'd bought as a teenager in Nebraska in 1979. He constantly had to wash it because it was plastered with dead bugs. Now, he said, he rarely has to scrape dead insects off his car. This phenomenon has been so widely noted it's become known as the "windshield effect."

Mile after mile of precisely planted fields flew by. Black shook his head. It used to be that farms in the valley were rimmed with weedy patches where insects could take refuge; today, he said, they tend to be plowed from one roadway to the next. "What I see is a lack of habitat."

Eventually we reached Bixler Ranch, in the town of Stockton. The 1,300-acre spread grows almonds and blueberries, and a few years ago its owners decided to work with Xerces to plant hedgerows and add back some of the native habitat that had been lost over a half century of increasingly intensive agriculture. One hedgerow had been planted in an old irrigation ditch and extended for more than half a mile. Taller shrubs like Woods' rose and elderberry alternated with smaller ones like white sage and western vervain. It was a hot, dusty day toward the end of summer, and most of the plants were looking thirsty. Even so, they were buzzing with leaf-cutter bees and sweat bees. "We have lots of data that show if you do this, they will come," Black said.

"Plants and insects are the fabric of this planet," he went on. "We're ripping it to shreds, and we need to knit it back together." □

Elizabeth Kolbert wrote *The Sixth Extinction* and is a frequent contributor. Photographer **David Liittschwager** focuses on the intricate beauty of the natural world. **Jason Bittel,** who wrote March's story on bees, reported from Costa Rica.

RISING TIDE
CAR WASH
REDEFINING SHINE

FINDING **WORK, LOVE, AND INDEPENDENCE** CAN BE ESPECIALLY DIFFICULT FOR THOSE ON THE **SPECTRUM.** BUT THERE'S **HOPE** THAT THINGS ARE STARTING TO CHANGE.

COMING OF AGE WITH AUTISM

BY **JUDITH NEWMAN**

PHOTOGRAPHS BY **LYNN JOHNSON**

Luke Zenda, 19, caresses his cheek with a vacuum nozzle at Rising Tide Car Wash in Margate, Florida. Tom D'eri started the business with his father to employ his brother and other autistic people. Family-run businesses that help autistic adults find work are increasingly common.

Madi.Hope.
STAR WARS

On her 11th birthday, Madi Haley dances to music in her bedroom in Key West, Florida. Three friends and her sister celebrated with her. While her friends are maturing, Madi's interests have stayed more childlike, but the girls are close and remain devoted to each other.

Headed to a dance, Brandon Drucker, 27, and Leah Nesenman, 23, canoodle as Leah's mother, Linda Gonzalez, does her best to pretend she's not there. Brandon and Leah still rely heavily on their parents, but both hope to live independently someday.

‘GUYS! REMEMBER: ABOVE THE NECK! OK, GO.’

We are practicing giving compliments at the PEERS Dating Boot Camp, a program for teens and adults with special needs who hope to find love. The participants, many with autism, are mostly in their mid to late 20s, but seem years younger. They come alone or with parents, caretakers, sometimes a sibling. Almost all live with their families. There’s lots of unfortunate facial hair, T-shirts from obscure bands (Radioactive Chicken Heads), noise-canceling headphones for the hearing-sensitive, plushy key rings hanging off backpacks.

Reading social cues is difficult for those on the spectrum, so everyone here wants to know the rules. And when it comes to dating, there are a lot of rules. Dating coaches, either doctoral students or administrators in the neuroscience program at the University of California, Los Angeles are trying to explain them.

For more than a decade, author Judith Newman’s son Gus (center), 18, has shown up nearly every Sunday at New York City’s Grand Central Terminal to hang out with the conductors. He knows all their names and their routes. He also likes handing out train schedules and giving directions to passengers.

A slight man in plaid flannel and khakis that seemed to be ironed on, frowns as he scans a female dating coach, looking for an in. His face brightens when he notices a tattoo on her ankle.

"Hey! I see you have a lambda. You like biophysics? Me too!"

"Neck up, I said. But OK, great!" the male coach leading the exercise says. "That was very nice; you established common interest."

The young man beams.

The male coach turns to a baby-faced man in a neat button-down shirt and asks him to try complimenting the female coach. She smiles encouragingly; he breaks into a flop sweat. Finally, words spill out: "I. Um. I … like the way your earrings sparkle against your pale white skin."

"Poetic!" the male coach says. "But we want to stay away from skin color, race, religion, and ethnicity at first, you know." The man, who is brown-skinned, nods and take notes. He was eager to explain himself, though. "If she is very pale, that means she's not out in the sun all day, working in the fields, like she's royalty."

Not helping, dude. Still, that would win my heart.

ADULTING IS HARD. Adulting as a person with autism spectrum disorder is harder.

Autism is a complex neurological condition that includes impairments in social interaction, language, and communication skills, combined with rigid, repetitive behaviors. (See the story on detecting autism, page 90.) The range of disability (and ability) is huge, which is why it's called a "spectrum" disorder, and the number of those affected is growing. In 2018 the U.S. Centers for Disease Control and Prevention published a study that found the prevalence was one in 59

Calvin Clark (at right) engages in “stimming”—repetitive self-stimulating behavior—inspiring a friend, Bennett Solomond, to dance. The boys were at Quest Therapeutic Camp in Pittsburgh, Pennsylvania. Calvin, 12, has been bullied, leading him to struggle with violent outbursts.

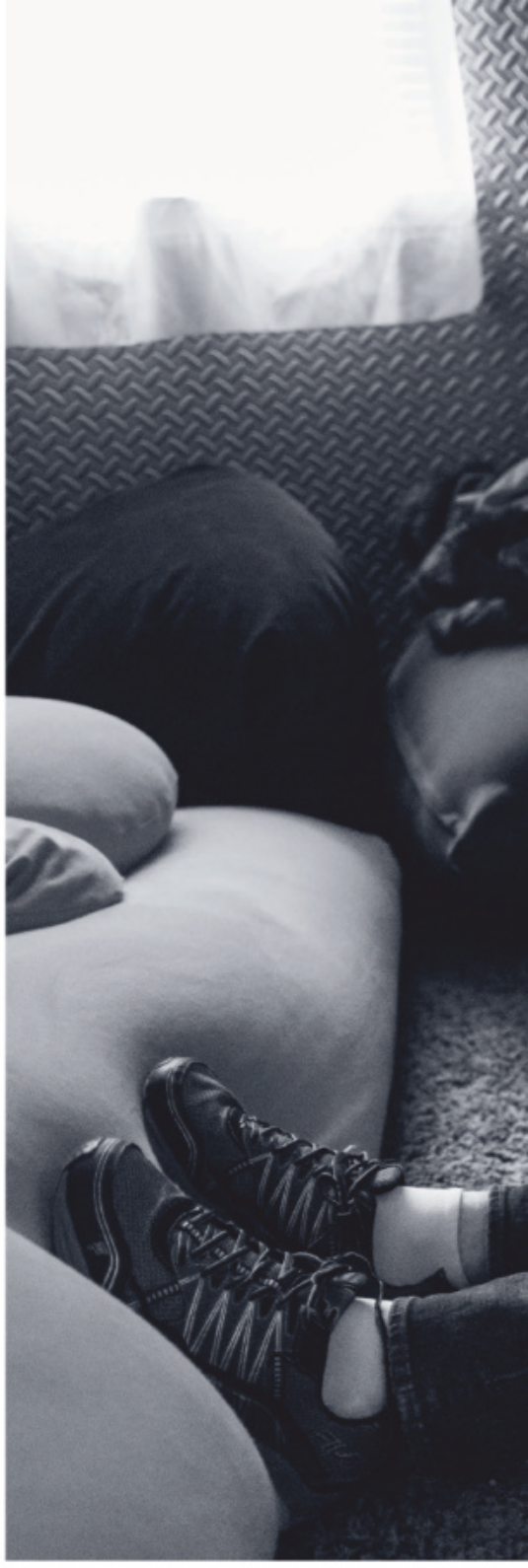
eight-year-olds, a 15 percent increase over two years. Why? That's a subject of heated debate. But one thing is certain: There's a rapidly growing population of adults with autism. In the United States, more than 700,000 will reach adulthood by 2030, according to Paul Shattuck, an associate professor of public health at Drexel University. Services for autistic adults fall off the cliff after they reach age 21. What will all these people do in their daily lives?

Data about employment vary significantly, but more than eight out of 10 autistic adults are thought to be unemployed or underemployed. Studies also show that the same number desire a romantic partner, but only a third to a half have one and fewer ever marry. If Freud was right—that love and work are the foundation of our humanity—we need to do better.

These issues are very personal to me. My autistic son, Gus, just turned 18. He's the kindest person you'll ever meet, with a confounding combination of strengths and weaknesses that makes me unable to guess if he'll ever live on his own. Why can he play the piano beautifully but can't cut his own food? Why does he love social media but can't help friending absolutely everyone, so his circle includes "Sex Worker Aboud" and enough sketchy "friends" to qualify for the FBI's watchlist? For that matter, why can he navigate New York City so easily but can't be trusted with money because he gives it away to anyone who asks? Recently I received a fraud notice on my credit card. It appeared the thief's purchases consisted of thousands of dollars of donations to Democratic causes. Yes, it was an inside job. When Gus was busted, he just said sadly, "But…I thought you wanted to ditch Mitch."

I think a great deal about what it will take to make my son independent. Some days, it's all I think about. I'm not alone. If there are more than an estimated four million autistic people in the U.S., there are surely a great deal more than four million neurotypical people who love them.

As Gus ages into adulthood, the list of his challenges that worry me grows longer. But the two questions that keep me up at night are: Will he find love, and will he find work that means something to him and allows him to at least partially support himself? I set out to see what I could learn.



Anat Klebanov calms her 21-year-old son, Gil, after he had a meltdown at JoyDew, a program in Midland Park, New Jersey. Klebanov and her husband, Moish Tov, started JoyDew to provide job training and employment for autistic adults, many of whom are nonverbal. The program tries to match the participants' skills to meaningful work, such as scrutinizing mammograms for anomalies. Besides Gil, the couple has another son, Tal, 23, with autism. JoyDew is an English translation of their sons' Hebrew names.

ABOUT A YEAR AGO a note was passed on to me. It was from a teacher at Gus's school. I had just published *To Siri With Love,* a book about raising an "average" kid on the spectrum, and I guess I did a lot of fretting. "I don't know wtf Judith Newman is talking about," the teacher wrote. "Gus will get a real job! He isn't going to need anyone's charity."

That's the best note I've gotten, ever.

It's true that more and more companies are recognizing the unique, and sometimes extraordinary, talents of autistic people. Some have set up special recruiting divisions. Microsoft and HP hold multiday hiring events to recruit autistic engineers and data scientists; JPMorgan Chase and Deutsche Bank also have seen the tremendous advantages of hiring those whose social skills may be iffy, or even nonexistent, but who have technical gifts. This is wonderful, but such whizzes represent only a small subset.

What about the regular (autistic) Joe, or Gus?

A lot of mom-and-pop concerns are filling this niche, generally started by a business-minded parent with an autistic child. On any given day I hear about new ones. Good Reasons in North Salem, New York, is a dog treat company that helps autistic people realize their "pawtential." (Note to owners: Just because you're helping people like my kid doesn't excuse this pun.) Coletta Collections in Washington, D.C., sells costume jewelry and hand-dyed scarves, featuring its artisans in profiles on its website. Two bookstores in New Jersey called Words, owned by a couple whose son is on the spectrum, employ mostly autistic help. Gus has interned at Luv Michael, which makes an organic, gluten-free, nut-free granola named after the autistic son of the founders, Lisa Liberatore and Dimitri Kessaris. Gus, who has the autistic person's very limited palate, doesn't eat granola. But his paycheck? He ate it up.

Luv Michael and many similar businesses are nonprofits. I wondered whether there were businesses that predominantly hired people on the spectrum and yet were still trying to make a buck.

I heard about Rising Tide Car Wash in two ways. First, from its viral video. In it, young adults washing cars combine insane car-cleaning attention to detail with, well, dancing. And then, from a friend in Parkland, Florida, who is a regular customer. "People don't go there to help autistic kids," she said. "People go because your car comes out spotless."

Tom D'eri is the co-owner; his autistic brother, Andrew, works there and was the inspiration. In 2011 D'eri and his father, John, started

Madi, seen celebrating her birthday in an earlier photograph, verges on a tantrum as she struggles with her homework. Her six-year-old sister, MacKenzie, watches her warily. "Homework is frustrating and confuses me," Madi says. "It sends my anxieties into overload, and my anger comes out, and that emotion is hard for me to keep under control."

researching a business that could be profitable and hire young adults like Andrew, who's 27. Rising Tide opened in 2013. A second opened four years later.

When I visit, D'eri asks a few workers to gather in the break room.

Luke Zenda, 19, is a great worker, with no filter. This is not just an educated guess. "I'm really good at this, and I have no filter," he says cheerfully, by way of greeting. His favorite part of the job? "Sometimes the breaks and sometimes the rain and sometimes the people. You have some things happen that make you question life."

I was a little afraid to ask what he meant, but I didn't need to ask. You've got the odd customer: "I once saw one just wearing a bra and just pants." And special items customers leave behind: "I found a condom in there, already used."

"What do you do in your spare time?" I interject quickly.

"After working here, it's like I want to go to sleep, and don't have to do cars," he replies, though he uses an epithet to describe the cars that captures both the exasperation and pride of the workingman.

Initially, D'eri wasn't sold on the idea. "I was not comfortable with the idea of employing people with autism," he tells me. "It was something that scared me for sure." The self-described my-way-or-the-highway manager had to learn to really listen so he could understand his employees. "You see, oh, oh my God, Melvin went from I think I was gonna have to fire him and I couldn't imagine a world where he was gonna be a good employee—this kid is now a rock star. He's like—I wish I had a hundred of him."

Jeff and Anthony shamble in. Both men are 32. When he's not cleaning cars, Jeff says he's a voice-over artist in training; he's also into puppetry. Anthony does a podcast called "A-Log on the Airwaves," playing comedy songs on *mad music.com;* he also does voices and gives me his Bernie Sanders. Anthony goes for some unprintable Bill Clinton banter, and then they both try out their Mr. T impressions. D'eri gently steps in: "This isn't a competition, gentlemen."

Asked what they like best about working at the car wash, Anthony answers unhesitatingly: "The camaraderie. So, like seeing the same faces," he says, "and also having someone to talk to while you're working. So, days when it gets boring. Right, Jeff?"

"Yeah," Jeff says. "We talk about what comes to our minds. And we speak from the heart."

That lack of inhibition had worried D'eri. But, he says, "we have way more behavioral issues with our typical employees."

It's just a matter of knowing the people who work for you, the quirks that might become a thing. "When we talk to other businesspeople about this, it's, 'You can really look at your employees with autism as extreme users of management and leadership,'" D'eri explains. "What they need is more observable than a regular employee. But what they need is no different than what anybody else needs. You can just see it a lot easier."

"THEY'RE FRIENDS," Steven Nesenman says emphatically.

We're trying to look like we're just strolling casually through this street fair in Lake Worth, Florida, even though what we're doing is closer to trotting. Nesenman is grim and determined; he doesn't want to lose sight of his daughter, Leah, for a second. Not because she would get lost, but because she is with her "friend," Brandon, and anything could happen. Maybe once or twice things did happen. But not on Dad's watch.

Leah is a gentle, shapely girl with piercing green eyes; she paints peace signs obsessively, collects lizard and frog figurines, and makes jewelry out of glass. She works at the Chocolate Spectrum, a candy shop—another business begun by a parent of an autistic child. Brandon too is an artist; he paints tiny, brilliantly colorful cartoon animals, flowers, and word diagrams. He sells his work online and in the Artists With Autism gallery in Pompano Beach, which was started by his mother and which he sometimes runs on his own. The two met seven years ago in an art class. They are in their mid-20s.

"I was born with a talent," Leah says, when we catch up. She can't exactly explain how she selects her glass, but clutches her necklace and says, "I like the colors. It makes you feel good. It's pretty. I like the greenness." They admire each other's work a great deal.

Earlier that day I'd visited Brandon in the small, airy apartment he shares with his mother, Cynthia Drucker. Brandon is a burly, handsome boy with a cowlick and a broad smile. When he was younger, he was impulsive, and while he never hurt anyone, he would slam things when he was angry. Drucker keeps a bound copy of Brandon's school reports from kindergarten on;

At Celebrate the Children in Denville, New Jersey, a student uses a virtual reality headset controlled by a teacher. The school, which has students ages three to 21, seeks to help students develop thinking skills, creativity, and flexibility to handle life's challenging situations.

I'M JUST HERE
FOR THE
POKEMON
(LEAVE ME ALONE)
OCEAN
A1

Christian Golon, 25, plays with his cat at home in Virginia. He manages a pet supply store, where he feels there are fewer social expectations to worry about. He is high-functioning; his wife, Catherine Betten-bender, is not on the spectrum.

sometimes she'll flip through them, to remember how far he's come.

Being unable to discern people's intentions combined with being a typical, amorous young man has gotten Brandon into more than a little trouble. A couple of years ago, Drucker felt Brandon was ready for a debit card. She learned she may have been a little hasty after he ran up $1,000 plus overdraft charges at a strip club.

Soon after, he brought home a prostitute who was looking for a place to hang out for a while, and his mother actually agreed. ("I thought I was gonna save another soul. What can I say?") When his money ran out and the woman wanted nothing more to do with him, Brandon was traumatized. But Drucker saw an upside. "Because he's had the experience, he knows what to do. He knows what the condom is only because of the experience with the prostitute," she says. "Something good came out of that. But for him to tell about the experience on the phone to his buddies, it's like, oh, my God." Drucker is, to put it mildly, a glass-half-full mom.

Brandon is eager to talk about Leah and the life he hopes they might someday share.

"I guess we would just take care of ourselves, and then, like, if she's ever sick, then I would just be giving her medicine," he says. He also promises to cook and do the laundry. Does this cover everything? Maybe not, but it's a good start. Brandon also says he wants to live with Leah and with Maria, another girlfriend. Uh... well... autism or not, Brandon isn't the first man to entertain such fantasies.

When I talk with Leah about her dreams for a loving relationship, she expresses the hope that it would be a step toward independence.

This talk makes her father deeply uncomfortable. What a struggle it is to raise an autistic child, he says, and what a toll it takes on a marriage. (He and Leah's mother are divorced.) I'm hardly a Pollyanna, but I see in Leah and Brandon what I desperately want for my own son. I try to get Nesenman to focus on what he has: A daughter who loves to create, holds a job, may need supervision, and maybe isn't up to caring for children, but seems to have a pretty good shot at having a relationship and living independently.

Nesenman doesn't see it that way. Well, yes, she has a job, but it doesn't pay, and anyway, she doesn't really understand the value of money.

Isn't he happy, though, that his daughter's found romance?

"You can't call it romance," he says firmly, "but it could be support, feeling secure, knowing what tomorrow's going to be like. You know, but that's the hard thing with autistic people. They want regularity."

I can't pretend to be objective; while understanding every worry he has, his attitude made me want to cry. Yes, autistic people want and need regularity. But is there anything wrong with wanting love too?

FRANK IS KNEADING DOUGH at a pizza joint at Rutgers University in New Brunswick, New Jersey. He is mostly nonverbal and severely autistic. What I am watching is a little bit boring and a little bit miraculous.

When Frank became one of the first participants in the Rutgers Center for Adult Autism

Denise Resnik instructs her son, Matt, 27, as he shaves, following instructions on an iPad. To help him live on his own, Resnik, a real estate developer, started First Place, a 55-unit independent living community in Phoenix, Arizona. Staff assist residents with daily tasks such as shopping, teach skills such as doing laundry, and connect residents to jobs that match their skills and interests.

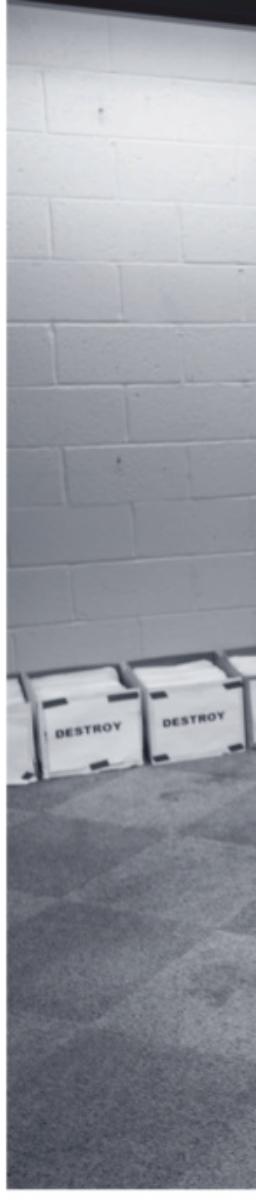
Services, he exhibited two behaviors pretty much nonstop: clutching his hands and screaming at the top of his lungs. These would not seem to bode well for gainful employment. But the Rutgers team discovered something else: Frank loved books, and he loved order. The program staff thought he'd love the library—but then, there was the screaming issue. Remarkably, saying the call numbers to himself while shelving the books competed with—and eventually squelched—the motivation to yell. But what about that clutching?

That's why Frank is spending his afternoons at the pizzeria. With a bit of finessing, Frank has been taught to make dough and form it into small rounds, which are then frozen. If you are forming pizzas, repetitive clutching is a feature, not a bug.

Eyes narrowed, Christopher Manente, executive director of the center, which is part of the Graduate School of Applied and Professional Psychology, watches Frank and his coach intently. "You know, people have this preconceived notion about autistic people, they're Temple Grandin or *The Good Doctor*—or they're completely debilitated. The extremes. So sometimes when I approach a company and ask them to take on one of our people, they think of it as just extra work. But it's really interesting, what can be worked out."

The Rutgers program conducts research and training for autistic adults across the spectrum—not just for specific pockets. It's the first program of its kind at a U.S. college. Twelve students are enrolled, but the program hopes to take up to 60. For now, they are commuters, but the idea

To_Do
In_Progress
Under Review


DESTROY
DESTROY

CLOCKWISE FROM TOP LEFT

Resting his chin on a hand, Brian McDermott, 35, listens to software development colleagues at JPMorgan Chase in Wilmington, Delaware. He finds the meetings stressful, even though he's a highly valued employee and his co-workers are supportive. He's one of 177 employees in the company's Autism at Work program.

A resident of First Place, Jenny Liebowitz, 26, is employed full time doing computer work for the Precisionists, a firm that creates jobs for people with disabilities. Jenny's work requires minimal interaction with people.

Christy Owens, 25, another First Place resident, works at a grocery store, rounding up carts from the parking lot and bagging groceries. She's an accomplished artist but prefers to do that purely for the joy of creating, rather than for money.

At Invictus Enterprises in New York City, 20-year-old Dusty Sweeney appears immersed in thought while working with dough to create healthy dog treats. The company was founded by Molly Sebastian and a friend, Alison Berkley. Sebastian has a daughter on the spectrum.

After an autism conference in Savannah, Georgia, mourners attend a vigil for people with disabilities who were killed by their caregivers. The organizer, Faye Montgomery, sits between her husband, William, and Temple Grandin. An animal sciences professor, Grandin has become one of the world's most famous people with autism. As a speaker and activist, she has inspired greater acceptance of people with, as she puts it, "differently abled brains."

is to create a live-work community where graduate students being trained to work with autistic adults live side by side with them.

Manente and I run around the campus, meeting trainees. Scott's favorite part of his waitering job at the diner is rolling napkins around silverware. Michael is in the fine-dining Rutgers Club, where he complains loudly that the job he wants is to be a greeter, but at the moment is utilizing his meticulous attention to detail to vacuum like a dervish. Stan, who is into aquariums and wizardry, works in the campus computer store; he struggles a little with the service aspect of the job because he is given to issuing very opinionated reports on the news of the day. They all have their eccentricities.

Surely they're more trouble than they're worth, right?

Manente introduces me to Sebastian Nieto, the manager of the Rutgers Club. We cram into his tiny photo-cluttered office. "Look, we're a college, a lot of times we're giving 'regular' students their first work experience," he says. "We put all this time and energy into training them. So why is this so different?" Nieto, who is from Argentina, looks at this from the perspective of an immigrant. "You come from another country, you don't know the language, you don't know the ways," he says. "You may be good, and you may be awful. But someone's got to put a little bet on you, even if it takes more work to get you where you need to be."

Nieto, who's familiar with Scott's work at the diner, notes that he wraps napkins around silverware better and faster than anyone he's ever seen—and furthermore, he really, really

likes doing it. "C'mon, hiring autistic people?" he says. "This is a no-brainer."

THE DATING CAMP is the brainchild of Elizabeth Laugeson, an associate clinical professor at the UCLA Semel Institute for Neuroscience and Human Behavior. A lot of social skills programs, a common treatment for people on the spectrum, are not that effective past a certain age.

"Most of the programs are focused on younger kids," she says. "Do you think that the social skills that you need when you were in grade school were different than the social skills you needed in middle school, in high school, and adulthood? Completely different."

Laugeson leads the boot camp all weekend, and she is kind, direct, and unflappable. Her mission: To decode the social-romantic-sexual world. "You don't get to date everybody, and not everybody gets to date you," she says, repeating it like a mantra.

Every possible facet of approaching another person is broken down and role-played: Flirting with your eyes (how to glance and look away—as compared to never looking in someone's eyes or staring like a zombie); getting into and out of conversations smoothly ("I gotta go to the bathroom" was revealed as a less-than-ideal exit strategy); the proper distance to stand during conversation (one woman was told she was too far away, then crept within six inches of the coach's face).

Slovenliness was emphatically discouraged. "It's disrespectful to your date," says Laugeson. In what I consider comical understatement, she says of people without good hygiene: "They rarely get a date."

The questions flew fast and furious. The participants want concrete answers in this, the most fluid of arenas. Laugeson tries to supply them. One important rule: If you ask someone out and they don't respond, you can ask once more and that's it. A petite woman in a 1950s-style plaid skirt raises her hand. "So … two messages a day?" "No. Two messages," Laugeson says. "Or a week?" "No." Trying again, the woman asks plaintively, "Just two messages an hour?" "Sorry," Laugeson replies.

There are rules even this psychologist can't supply, like the odds of getting a goodnight kiss on a first date. "What's the percentage of times you get the kiss?" asks a math-loving guy.

Several people want to know whether they should disclose their autism diagnosis. For this, Laugeson says, there is no rule. For some it's a yes. They are out and proud. For some it's a no. But if you do tell, she says, "don't make it a negative. Say what it means to you." She tells them to say all the good things, like, people with autism tend to follow rules, they tend to be loyal, they will tell you what they're thinking.

It's a lot for these daters-in-training to take in, but they're hopeful. Me too. For all of them, for our society, for my son—and especially for the bespectacled young man sitting next to me, who nods and mutters happily under his breath: "I can do this. I am boyfriend material." □

Judith Newman wrote *To Siri With Love,* a best-selling memoir about her autistic son, Gus. **Lynn Johnson,** a frequent contributor, last photographed influential women around the world.

FINDING EARLY SIGNS OF AUTISM

The brains of infants who develop the disorder grow too fast, researchers say. The discovery could help doctors prevent impairments before they appear.

BY **YUDHIJIT BHATTACHARJEE**

PHOTOGRAPHS BY **LYNN JOHNSON**

FOR PARENTS WHO LEARN their child has autism, the diagnosis often comes as a shock: How could their baby have gone from appearing healthy to having an incurable disorder? Since autism was first identified in the 1940s, researchers have struggled to explain it. The cause remains a mystery, but scientists are beginning to learn what happens in the brains of these children.

Studies indicate that it may be possible to detect signs of autism at as early as three months of age, long before the disorder manifests itself. Early detection would allow for interventions that might prevent or mitigate the impairments associated with autism.

"What we are learning is that autism is a trait, and whether or not that trait becomes a disability depends on early experiences," says Ami Klin, a psychologist at Emory University. That raises

Alia Aamar soothes her 10-month-old daughter, Aneesa, before researchers scan her brain in Joseph Piven's lab at the University of North Carolina at Chapel Hill. Aneesa has an older brother with autism, so she has a greater likelihood of developing it. By regularly scanning the brains of babies who might develop autism, the researchers hope to pinpoint brain changes that could be used to help make an early diagnosis.

the possibility, he adds, "that autism as a profound disability is not inevitable."

Scientists know that autism can be caused by a number of genes, both inherited and mutated, as well as other factors, such as the advanced age of a parent. One fraudulent study blamed it on the childhood vaccine for measles, mumps, and rubella—a provocative claim that has been disproved. Since the late 1990s, the disorder has become increasingly prevalent. Researchers believe that's partly explained by improvements in diagnosis, but they haven't ruled out the possibility that the incidence is increasing, possibly due to biological and environmental factors.

Although researchers haven't established the precise origins of autism, they're gaining a clearer view of how it progresses.

Joseph Piven, a psychiatrist at the University of North Carolina at Chapel Hill, and his colleagues studied 106 infants who had an older sibling with autism, which meant they had a higher chance of developing the disorder. Scanning their brains at six months and again at 12 don't emerge until about two years after birth, which is when most children are diagnosed. "We are talking about detecting them at a time when they just have some risk markers," Piven says.

Children with autism undergo interventions to help them socialize and communicate, lessening the severity of their impairments. With earlier detection, Piven and his colleagues contend, it eventually might be possible to take preemptive action, either through behavior modifications or medication, "that would change the trajectory of the brain."

In 2018 a research group led by Charles Nelson, a neuroscientist at Harvard Medical School, published results showing the viability of detecting autism risk in three-month-old infants by mapping the electrical activity in their brains using an electroencephalogram, or EEG. The researchers conducted the exams on children between the ages of three months and three years. Nelson and his colleagues found that the activity in the brains of infants who were later diagnosed with autism stood out from the rest.

The latest research raises the possibility that babies who are at risk for autism could be nudged onto a remedial track.

and 24 months using magnetic resonance imaging, the researchers found striking differences between the infants who later developed autism and those who didn't. The brains of infants who were subsequently diagnosed with the disorder grew faster than the others starting at six months, expanding more in surface area until 12 months, and then became larger in volume in the second year of life, the team reported in 2017.

The link between brain overgrowth and a subsequent diagnosis of autism was so strong that the researchers could use the brain scans at six and 12 months of age to accurately predict an autism diagnosis for eight out of every 10 infants who were found to have the disorder. Scans tracing abnormal brain changes have the potential to allow pediatricians to spot autism well before symptoms appear. The deficits that characterize it—language delays, difficulties with social interaction, and repetitive behaviors—usually

"At as early as three months, we see patterns in the EEG that tell us which subset of those children will develop autism," Nelson says.

What these studies reveal about the atypical nature of brain development in the lead-up to autism appears to be consistent with behavioral findings by Klin and his colleagues. Along with Warren Jones, a neuroscientist at Emory, Klin and others tracked the eye movements of babies as they watched videos.

Infants between the ages of two months and six months who spent less time looking at people's eyes than typically developing infants were likely to be diagnosed with autism as toddlers, the researchers found. In a study with toddlers, they found that those with autism gazed half as often at faces and twice as much at objects.

The results suggest that infants who go on to develop autism see the world in a fundamentally different way. This profoundly alters how they

Piven, cradling 3D-printed models based on brain scans, has studied autism for 36 years. The psychiatrist believes children who develop autism take in their surroundings differently. "It's a problem with how you're experiencing the world through your senses and through your attention systems," he says. Piven hopes an understanding of the brain development seen in autism will lead to drug treatments: "I think that we're going to be using targeted medications for particular subtypes of autism."

handle social interactions, which in turn has a cascading effect on their brain development, possibly leading to later impairments. "What seems to be happening is that our children with autism are missing thousands and thousands and thousands and thousands of experiences of social learning," Klin says.

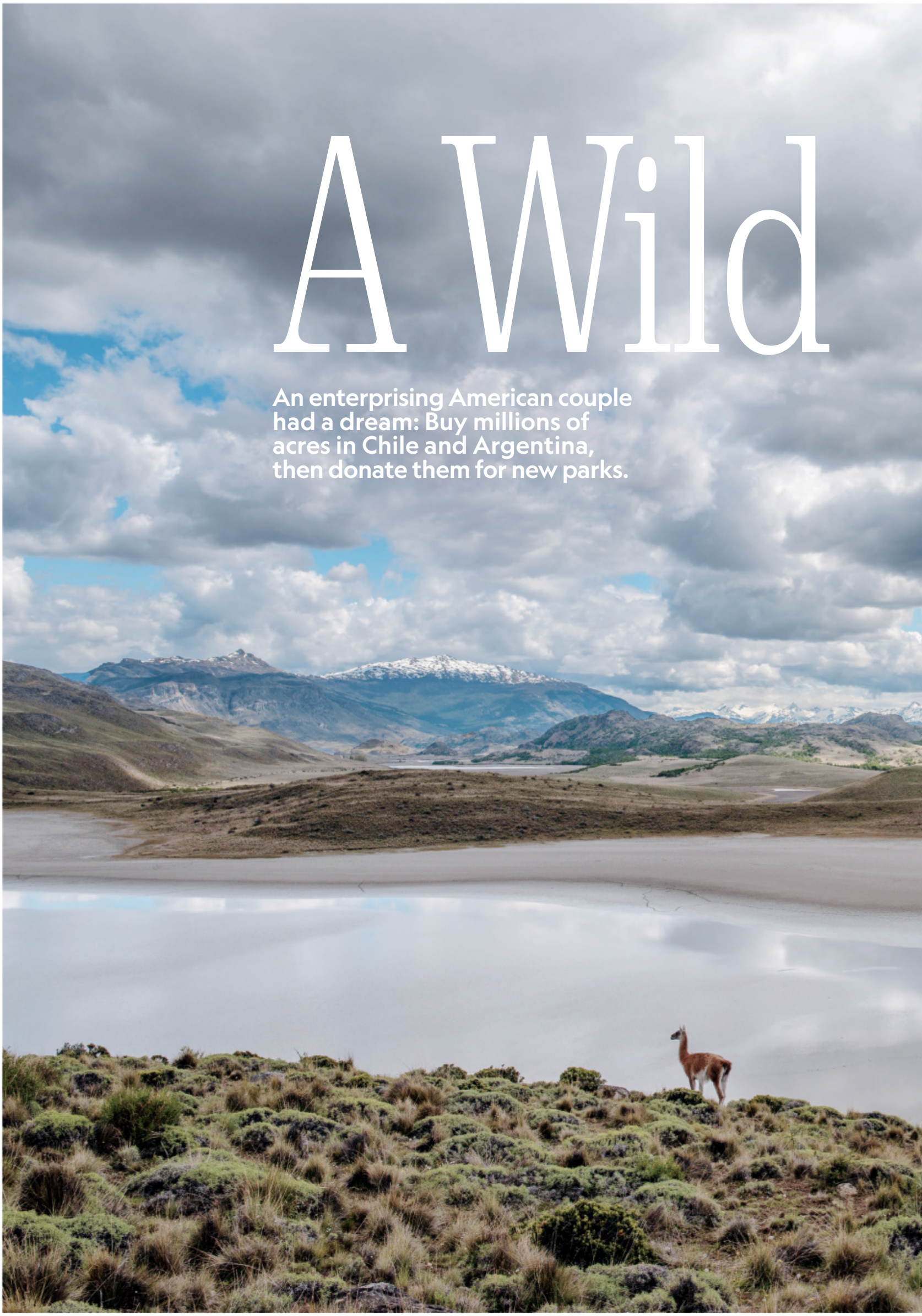
The findings imply that babies at risk for autism could be nudged onto a remedial track. Researchers have been testing behavioral interventions such as the Early Start Denver Model, a program that teaches parents and therapists to use specific strategies, including play, to develop social and language skills development in children with autism. A recent trial involving 118 children found that the intervention improved language ability, which researchers say is one of the best predictors of long-term gains for individuals with autism.

Geraldine Dawson, a Duke University psychologist who helped create the model, says, "What we want to do, as early as possible, is to bring the baby back into the social world, so they're paying attention and getting that early enrichment." □

Yudhijit Bhattacharjee, a contributing writer for *National Geographic,* wrote about the latest research on pain for the January cover story.

A Wild

An enterprising American couple had a dream: Buy millions of acres in Chile and Argentina, then donate them for new parks.



Idea

BY DAVID QUAMMEN

PHOTOGRAPHS BY
TOMÁS MUNITA

Veterinarian Jorge Gómez monitors a red-and-green macaw training for release into Iberá Park, Argentina. Not seen in the region for a century, the species is being brought back, as birds raised in captivity are taught skills they'll need to survive in the wild.

PREVIOUS PHOTO

A guanaco, the wild form of the llama, arrives to drink at Laguna Seca in Chile's Patagonia National Park. The 750,000-acre park combines public land with private property donated by Tompkins Conservation.

With his horse in tow to ride later to his home, Mingo Avalos poles his canoe through a channel, as he and another guide lead tourists in Iberá. Tourism is a win-win: Former hunters and ranch hands like Avalos gain eco-friendly jobs; visitors learn from their intimate knowledge of the landscape.

LAST WILD PLACES

Tompkins Conservation is a conservation partner of the National Geographic Society's Last Wild Places initiative.

'It was a desperate time. Doug never got over it.'

KRIS McDIVITT TOMPKINS SITS BEFORE A COFFEE table covered with colorful maps of Chile and Argentina, talking about the controversy in the early 1990s that swirled around a place called Pumalín, in southern Chile. Pumalín was the chastening early experience that showed her and her late husband, the retired businessman and adventurer Doug Tompkins, how hard it could be to convert Yankee dollars and good intentions into landscape protection in South America. ¶ Beyond the coffee table, beyond the maps, beyond the big windows of this handsome stone guesthouse, built like an aerie atop a small hill, stretches a vista of rolling grasslands, tumbling streams, forests of southern beech, and midnight blue lakes: the stern natural glories of Chile's Patagonia National Park, another Tompkins project. ¶ The park comprises more than 750,000 acres, including the Chacabuco Valley, running west from the Andes. Together with Pumalín, some 300 miles to the north, and six other parks—created or enlarged by Tompkins persistence, in partnership

GIJS BESSELING

Kris Tompkins of Tompkins Conservation pauses near La Pepa lagoon in Chile's Patagonia National Park. The recovering forest shelters a slowly increasing population of huemuls, an endangered Andean deer. "Landscape without wildlife is just scenery," she says. Her husband and partner, Doug Tompkins (left, with Kris in 2010), died in a kayak accident in 2015.

with the Chilean government, and leveraged with Tompkins-donated lands—this network of wild places totals more than 11 million acres. The breadth and diversity are vast, spanning the length of Chile's southern half, from the Valdivian temperate rainforest of Hornopirén to the rocky islands and glaciers of Kawésqar. But to understand the scope of what Kris Tompkins and her husband have done, as well as the obstacles they have faced, it's best to start with Pumalín. She unfolds the maps and tells me the story.

In 1991 Doug Tompkins bought a derelict ranch in the Lakes Region of Chile, a country he knew from youthful visits as a vagabond skier and climber in the early 1960s. Later in that decade he and his first wife founded the outdoor equipment company The North Face, sold that business for not much money, then established the highly successful clothing company Esprit. By the start of the 1990s, by then quite rich, divorced, and disenchanted with ravenous consumerism, Tompkins had cashed out and walked away from the business world, devoting his life to the robust sports that first brought him south—mountaineering, skiing, kayaking—and also to conservation.

His plan to restore the ranch's native vegetation morphed into a bigger idea. He created and endowed a private foundation, the Conservation

The nonprofit National Geographic Society helped fund this article.

Land Trust, and through it made purchases to assemble two big blocks of mostly wildland, Pumalín North and Pumalín South. Between them lay another parcel, called Huinay, then owned by the Pontifical Catholic University of Valparaíso, which was willing to sell. But powerful political interests, including then President Eduardo Frei Ruiz-Tagle, opposed the sale. Kris McDivitt entered the picture at that point, having recently retired as CEO of another clothing company, Patagonia, and bringing her own wealth and convictions, which aligned well with those of Doug Tompkins. She and Tompkins were married in 1994.

Kris Tompkins is a small, forceful woman with a clinical intelligence; she reminisces without emoting. Huinay, yes, that was the piece that would have united Pumalín, she tells me. It amounted to roughly 130 square miles, not large compared with Pumalín North or South, but belting the Chilean mainland at one of its narrowest points, from the Gulf of Ancud to the Andean summits. Their efforts to buy it aroused suspicion, resistance, rancor. They were taking agricultural land out of production, some people groused, with all this buying and protecting. They were killing jobs. They were shaping "a fiefdom" in Chile.

Such reactions continued throughout the 1990s and into the early years of this century, as the couple expanded their land buying and protection to other parts of Chile (including the Chacabuco Valley, where she and I now sit). Who were these grasping gringos, and what nefarious plans did they have? Were they looking to build a nuclear waste dump or provide military bases for Argentina or steal away Chile's water? Or did they just want to turn large chunks of Chile into their own private getaways?

In reality their goal at Pumalín was to buy land, create a park, and give it to the nation. But Chile had no tradition of private philanthropy outside of church and education projects. Such unfathomable generosity from a pair of Americans seemed patriarchal at best, sinister at worst. Huinay was especially sensitive because, though smallish, it stretched from border to border. If rich gringos owned that property, critics argued, the country would be cut in half.

"We had four or five years of being despised," Kris Tompkins says. "People thought we were a cult."

THROUGHOUT 21 YEARS of marriage, with their multiple far-flung properties and projects in Chile and Argentina and their restless interest in landscape, the Tompkinses spent considerable time in small, private airplanes. He had 15,000 hours as a pilot. She took the controls often but, never licensed, not for landings or takeoffs. "That's when I'm happiest, flying," she tells me. They always thought they would die together, she adds, because of all that bouncing around in the Cessna or the Husky amid these Andean canyons and peaks.

It didn't happen. He died of hypothermia on December 8, 2015, at a hospital in the regional capital, Coihaique, after suffering prolonged immersion in a cold Chilean lake on a disastrously unlucky day, when the winds came up, the waves rose high, and the rudder on his kayak

LEFT

As volunteer Erik Esposito looks on, biologist Pablo Guerra tends to Nahuel, an 18-year-old breeding male at the Jaguar Reintroduction Center on San Alonso island within Iberá Park. Cubs born here are kept free from human contact, maximizing their chances of survival after release into the wild.

BELOW

Biologist Giuliano Pesci checks up on a radio-collared female tapir and her calf released in Iberá Park. The rewilding program was later suspended after five tapirs succumbed to an exotic parasite. Iberá's six surviving tapirs are in quarantine.

Gaining Ground

Since the early 1990s, the American foundation Tompkins Conservation (TC) has purchased more than two million acres of private land in Chile and Argentina, donating it to those countries to help establish or expand 14 national parks. In Argentina's Iberá Wetlands (below) efforts are under way to reintroduce species into the wild that have been locally extinct for decades.

Protected patchwork
Iberá Park is a mosaic of national and provincial lands. Neighboring Iberá Natural Reserve is under provincial control.

Achieving stability
A reintroduced species is considered stable once births exceed deaths and the population grows without human intervention.

Bringing back species
Rewilding aims to restore predators, herbivores, and seed dispersers. Plans include the release of two predators: jaguars and giant otters.

INTO THE WILD

145

Collared peccary
(Pecari tajacu)
reintroduced since 2015
stable population

88

Giant anteater
(Myrmecophaga tridactyla)
2007, *stable*

41

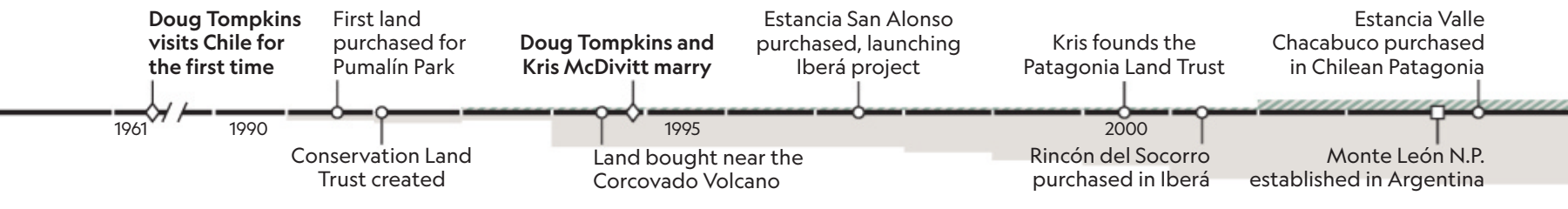
Pampas deer
(Ozotoceros bezoarticus)
2009, *stable*

28

Red-and-green macaw
(Ara chloropterus)
2015

MILESTONES AND ACQUISITIONS

Land owned by Tompkins Conservation
Land donated by TC
Parkland donated by Chile and Argentina


Doug Tompkins visits Chile for the first time
1961
1990
First land purchased for Pumalín Park
Conservation Land Trust created
Doug Tompkins and Kris McDivitt marry
1995
Land bought near the Corcovado Volcano
Estancia San Alonso purchased, launching Iberá project
Kris founds the Patagonia Land Trust
2000
Rincón del Socorro purchased in Iberá
Estancia Valle Chacabuco purchased in Chilean Patagonia
Monte León N.P. established in Argentina

CHRISTINA SHINTANI, TAYLOR MAGGIACOMO, AND IRENE BERMAN-VAPORIS, NGM STAFF. SOURCES: TOMPKINS CONSERVATION; REWILDING ARGENTINA

Iberá Park

1997—2018: years TC involved in park creation

17% of parkland donated

8 active rewilding programs

Pumalín Douglas Tompkins National Park

1991—2019, **73%**
30 community properties restored

Corcovado N.P.

1994—2018, **21%**
About 600,000 acres of primeval rainforest

Patagonia N.P. (Chile)

2004—2018, **27%**
400+ miles of ranch fencing removed

Kawésqar N.P.

2001—2019, **1%**
136 species of birds

Patagonia N.P. (Argentina)

2012—2015, **51%**
7 pumas actively monitored

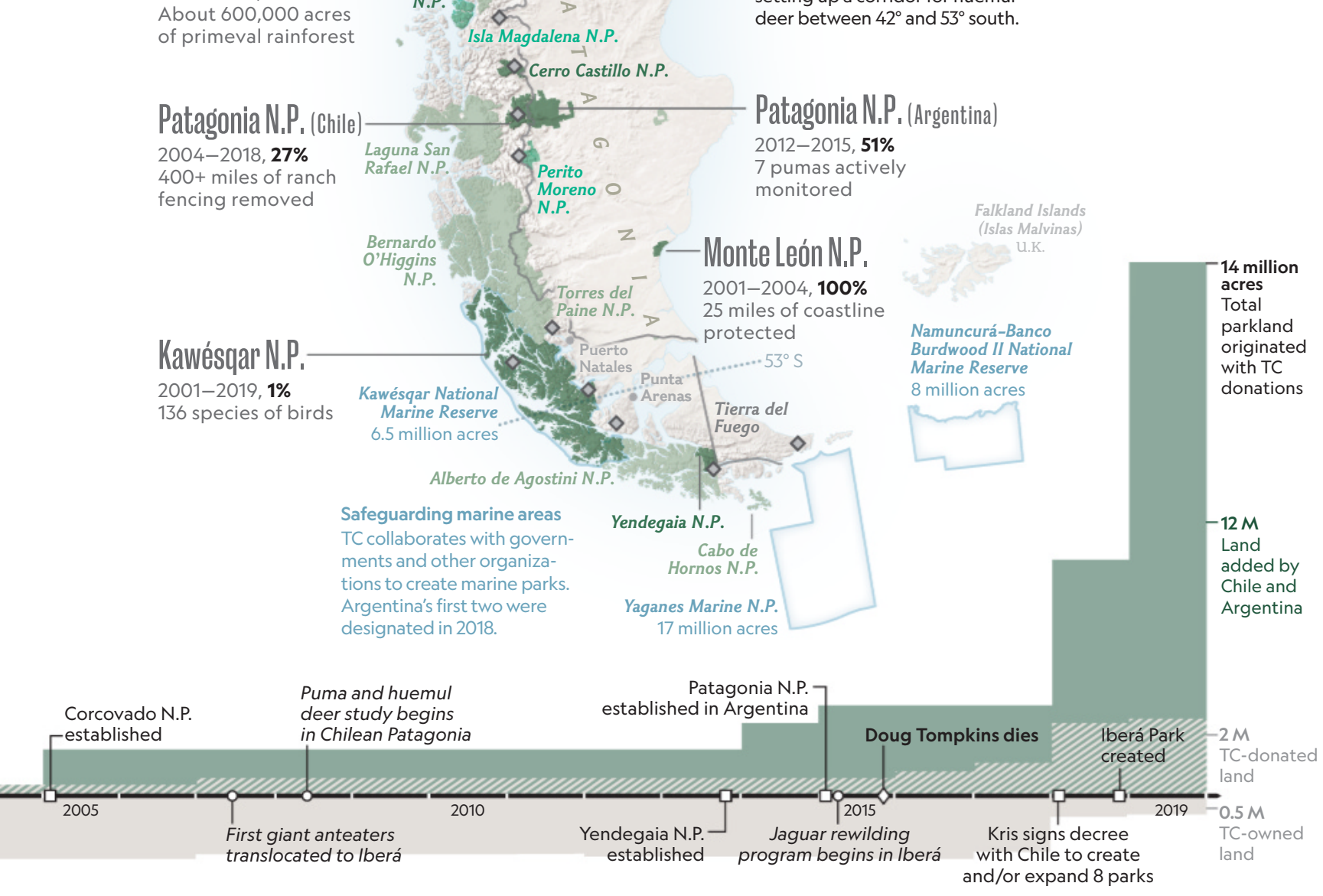
Monte León N.P.

2001—2004, **100%**
25 miles of coastline protected

Safeguarding marine areas
TC collaborates with governments and other organizations to create marine parks. Argentina's first two were designated in 2018.

Conservation efforts
- Park created with Tompkins Conservation land and/or funds
- Existing parks expanded by TC
- Other protected lands
- Marine park affiliated with TC
- Ongoing TC project

Works in progress
There are 16 ongoing projects: land TC has bought but not yet donated. The organization is setting up a corridor for huemul deer between 42° and 53° south.



LEFT

Veterinarian Jorge Peña provides critical care and a warm lap to a pampas deer en route to its new home in Iberá Park. The sedated animal was one of several translocated by helicopter from an area squeezed by encroaching tree plantations.

BELOW

A pair of young Darwin's rheas born at a breeding center size up an acclimation facility where they'll stay for one to two months before being released in Patagonia National Park, Chile. The rewilding program aims to release 10 to 20 of the flightless birds a year.

malfunctioned. The boat capsized, and the driving chop kept him and his paddling partner, the renowned climber Rick Ridgeway, from reaching shore. Ridgeway was rescued after an hour and survived, Doug Tompkins did not.

Kris Tompkins got the news by phone—a vague version, about an accident and maybe a fatality—then drove six hours to the hospital where her husband had been pronounced dead. "Him leaving so quickly matches whatever that marriage was," she tells me. "Grief is just a continuation of whatever the relationship was that you had." Intense lives shared, intense grief. So be it.

Her aviation nickname during their years together, for communicating by radio, was "Picaflor," Spanish for "hummingbird." Doug Tompkins's handle was "Águila," meaning "eagle." Between the two of them, more intimately, those transmuted to "Lolo" for him and "Birdie" for her. But if she is birdlike, it's in the manner of a storm petrel, buffeted and doughty, not a hummingbird. For the past few years, she has pursued alone only more fervently what they began together.

"It's what kept me from going with Doug," she says. Giving up, she means, lying on the widow's pyre. "I couldn't imagine life without him."

Instead she refocused on their goal of leveraging Tompkins landholdings into a wondrous portfolio of national parks, scattered across Chile and Argentina. That took three years, but it accelerated quickly. Within two weeks of burying her husband, she reached an agreement to protect an enormous wetlands ecosystem known as Iberá, in northern Argentina. And by the end of March 2019, she finalized her commitment with the government of Chile to combine one million acres of Tompkins land with 10 million acres of government-held land to create five new national parks and enlarge three others. What once was the private reserve of Pumalín is now a public treasure: Pumalín Douglas Tompkins National Park.

AFTER LUNCH at the guesthouse, Tompkins takes me walking to see some of the local landscape. Behind the main lodge of Patagonia National Park, a service road leads to a footpath up a creek drainage. We pause at a very small cemetery, squared within a stone-pillared fence, with 10 graves marked by wood crosses and small shrines, plus one vertically planted slab of stone, upon which is carved:

DOUGLAS RAINSFORD TOMPKINS
BIRDIE & LOLO
03-1943 12-2015

Staff members chose the headstone inscription without consulting her, but Tompkins says it suits her fine. She is briskly unsentimental in her conversations about her husband and his end, but unsentimental is not unemotional, and sometimes, she tells me, she comes back to this gravesite and lies on the grass quietly, remembering, communing.

The foot trail snakes out across stony hillsides and grassy flats tufted with neneo bushes, yellow flowered and spiny, rounded in profile so that from a distance they look like coral heads. It crosses a creek, shaded by beech trees, then climbs toward a campground, simple but well

Corcovado Volcano towers above Chile's Corcovado National Park. The late Doug Tompkins, an adventurer as well as a conservationist, scaled the peak in the 1990s. The park was formed in 2005 by fusing federal lands with properties donated by Tompkins Conservation and philanthropist Peter Buckley.

Near his town in Santa Cruz Province, Argentina, Daniel Reber stands over a guanaco kill, which will be used to feed his dogs. Hunting guanacos without a permit is a common, if illegal, practice in the province. A nearby national park provides 200 square miles of safe haven to wildlife.

kept for visitors, and loops back toward park headquarters. At one point, I notice a small pile of dried, bone white scat. Yes, puma, Tompkins says, picking up a lump and breaking it open to show me the compacted fur. The increased puma population in the Chacabuco Valley is one dimension of rewilding, a major goal for Tompkins lands in Chile and Argentina that have lost signature elements of their aboriginal fauna. Rewilding means more pumas and huemuls (south Andean deer, an endangered species) and Darwin's rheas (a large, flightless bird) here in Patagonia National Park, plus other wildlife restoration and reintroduction elsewhere.

Rewilding is also controversial, especially when it involves the return of predators such as the puma or (up in that great Argentine wetlands, Iberá) the jaguar. Only a combination of daring and patience could make it happen, and much of the patience is Kris Tompkins's.

"Doug was the bomb thrower," I was told by Gil Butler, a peer in conservation philanthropy. "Kris is, 'Let's go get it done.'"

ON THE ARGENTINE SIDE, Tompkins rewilding initiatives are proceeding busily at Esteros del Iberá, in the northeastern corner of that country. It's a vast, soggy ecosystem, a paisley mosaic of marshes, dark-water channels and sloughs, lagoons, platforms of floating vegetation, hummocks just high and dry enough to support tiny patches of forest, and some areas of solid savanna. Caimans and waterbirds are abundant, and with luck you can spot a yellow anaconda. Sunshine presents it all brilliantly—the name itself is from the Guaraní language, *y berá,* and means "shining waters."

Iberá lies within Corrientes Province, a mostly rural region bordered by Paraguay, Uruguay, and Brazil, with a strong element of native Guaraní culture and language and an ethos of frontier independence. Iberá's history for a century included marginal cattle ranching, as well as hunting for meat and hides; local people often traveled by boat or wet-footed horse, but there wasn't enough terra firma to support many humans or cows. The alternative future was trending toward commercial-scale rice farming and pine plantations.

Then, in 1997, Doug Tompkins happened to visit. He became intrigued with the place and, one summer day, flew his wife back for a look. "We got out of the plane, and I just said, Hey, let's

get out of here," she tells me. "It's hot, it's buggy, it's flat as a pancake. Get on the plane." But he saw something she didn't—its biodiversity, its possibilities—and bought a ranch on an island amid this great swamp without even discussing it with her, a rare thing. That ranch, Estancia San Alonso, became the first Tompkins foothold in Iberá and, eventually, because of its remoteness, a logical site to begin the most dramatic act of rewilding: the reintroduction of jaguars.

Not far from the San Alonso ranch house stands a cluster of well-engineered enclosures: stout rebar fencing and steel poles, 16 feet (five meters) tall, T-shaped at the top to prevent animals from climbing out, electrified wire around the inner perimeters. Jaguars can be restless, especially when caged, and athletic.

Each enclosure also contains a tree platform,

LEFT

Ranch manager Baruki Perez pauses after an unsuccessful fox hunt on his family's estancia in Santa Cruz Province, his dogs bloodied from running over sharp rocks. Foxes and pumas pose a threat to the 6,000 sheep on the estancia, which is sandwiched now between two parks.

BELOW

Ranger Emanuel Galetto lifts a sedated female puma caught in a no-injury leg trap set by biologists in Argentina's Patagonia National Park. She'll be fitted with a GPS collar and released, joining six other collared pumas tracked in the park.

A Magellanic penguin appears unperturbed by a passing herd of guanacos in the Punta Tombo reserve on Argentina's Atlantic coast. Tompkins Conservation is starting to buy coastal land south of the reserve for its marine park project, Patagonia Azul.

low brush, or some other natural furniture to provide cover. Eight jaguars were in residence when I visited, including several adult breeders borrowed from zoos and a pair of year-old cubs, born there and being raised for release. The cubs inhabited a larger pen at the back, with plenty to eat but no human contact—even glimpses of their keepers minimized—so that when liberated, they would fear people, not associate them with food, and possess other good, wild survival habits.

I watched as a live capybara—a native rodent, huge and meaty—was introduced to one pen; but the adult female inside either wasn't paying attention or wasn't hungry. She would find it in due time. A big male jaguar known as Nahuel paced back and forth along a fence line, muscles rippling under his smooth, patterned fur.

These cats are ferocious as well as beautiful, of course, and will kill livestock in any area where cows and sheep have supplanted their natural prey. The San Alonso island is now cow- and sheep free, its grass supporting many marsh deer and an almost comical abundance of capybaras (thanks in part to the long absence of their jaguar predators), some of them topping 150 pounds. That's why San Alonso is the right place to start. The first releases may happen soon. Reestablishing jaguars throughout a wider area of Iberá will be more complicated, requiring both social acceptance and available wild prey.

Tompkins Conservation is addressing that with a campaign of education and events, intended to nurture jaguar appreciation as part of the proud legacy of Corrientes Province. At a first-birthday party for the two jaguar cubs, in the town of Concepción, I watched more than a hundred people, adults and kids, celebrating in a courtyard amid brightly painted animal murals, guitar and accordion music, small children twirling colored streamers, free cookies in the shape of a jaguar paw, and a puppet show. Kids took turns posing for pictures in front of a huge jaguar poster, each kid delivering a jaguaresque roar. *"Corrientes Ruge,"* read the poster legend—Corrientes Roars.

THE REWILDING EFFORT also involves red-and-green macaw, pampas deer (a threatened species), collared peccary, giant otter, and giant anteater. Some of the preparatory work with those animals occurs at a quarantine compound, down a narrow side road and behind two layers of fencing, near the town of Corrientes, the provincial capital.

A local woman named Griselda "Guichi" Fernández, who formerly worked as a cook and cleaner and joined Tompkins more than a dozen years ago, is now the expert foster mother to the little orphaned anteaters raised here, each of which has its own pen. Fernández offered a bottle to one, known as Quisco, which clung to her lovingly as his very long snout found the nipple and his noodlelike tongue came out to lap the milk. After the feeding, he luxuriated in the attention as Fernández tickled his tummy; but that easy intimacy couldn't last.

"They are such instinctive animals, they can't be raised as pets," she said. "After they're a year old, they have big claws and they're dangerous."

'We had four or five years of being despised,' Kris Tompkins says. 'People thought we were a cult.'

Such orphans often are left behind when the mother is killed in an altercation with a hunter and dogs, during which a dog sometimes dies too. An adult giant anteater is a magnificent, improbable creature with brindle fur down its back, white chaps, a racing stripe of black, a huge furry tail that can serve as a blanket when it sleeps, a gracefully curved snout that works like a vacuum attachment, a tongue half the length of its body, and those claws. Eight adults resided in larger pens not far from Quisco's, and when Fernández arrived with their dinner—a slurry of cat food and water, since their caretakers can gather only so many ants in a day—two came promptly to lap it up. Once released to the wild, they would revert by instinct to a diet of ants and termites.

THE STRUGGLE to rewild Tompkins properties at Iberá, to combine them with government lands (both national and provincial) into a great public park, and to nurture tourism-based economic development in communities around the wetlands' perimeter, has been long and

fraught. Sofía Heinonen, now executive director of Tompkins Conservation in Argentina, who started managing the Iberá project in 2005, told me that people first spoke of Doug Tompkins as "the gringo who wanted to steal the water." It became an opposition slogan: *"Los gringos vienen por el agua*. The gringos are coming for the water." Argentines found difficulty—as had Chileans, during the Huinay time—in believing that two rich Americans would buy land in order to give it away. Some officials of Corrientes Province also were suspicious of the big-park vision, as were major local landowners, embracing the older economic model of cattle, forestry, and rice.

Support from Corrientes officials was critical because, apart from Tompkins properties and land held by the national government, much of Iberá belonged to the province. "We knocked the door, we knocked the door," Heinonen told me. Corrientes officials wouldn't open it. But mayors of the small towns surrounding the wetlands, gateways to the ecosystem, were showing more interest in the potential tourism revenue from a big park. And the national government in Buenos Aires, especially the Ministry of Tourism, also saw Iberá as a promising new destination. By 2013, at least one politician in Corrientes, Senator Sergio Flinta, realized that the province was on the wrong side of this fight and began pushing park-creation bills in the provincial senate. But it was still a deadlock. Then an event broke the impasse: Doug Tompkins died.

Immediately, amid her grief, Kris Tompkins took action. She told Heinonen to call Flinta and close the deal on compromise terms—involving 415,000 acres of Tompkins land, plus Corrientes provincial land, plus Argentine national land, all linked (but no sovereignty subsumed) to form a single great park. Within two weeks Tompkins, Heinonen, and Flinta were in the office of Mauricio Macri, Argentina's new president, and the deal was made. Tompkins could have worn widow's black to that presidential meeting, playing on sympathy, but she turned up in a white sweater and managed a smile, expressing the implicit message: Enough political quibbling, life is short. Let's get it done.

Five years on, former critics have come to see both the heritage value of rewilding and the economic benefits of tourism. "There were people who didn't like Doug because he was a Yankee," Flinta told me. "And now they say thank you."

BACK IN PATAGONIA National Park in Chile, I ride up the Chacabuco Valley one day with a bird guide to view Chilean flamingos and grebes and coots and other waterfowl from an overlook above Lago Cisnes, Swan Lake, a reed-rimmed widening of the Chacabuco River. The namesakes are there too: black-necked swans, so elegantly pied, and little coscoroba swans, white-faced, with black wing tips. At the lake's west end, *álamo* trees (known elsewhere as Lombardy poplars), shade a table and a small sign: *ÁREA DE PICNIC PICAFLOR Y ÁGUILA*. Lolo and Birdie first camped at this spot in 1993, on their way to explore Argentina, and returned to it nearly every year until his death. Today a family of Chileans from a nearby town, with their Santiago visitor, are sharing lunch at the picnic site. I speak with the wife, a lawyer named Andrea Gómez Jaramillo. Yes, she says, we have come here before, we enjoy the wildlife, the guanacos are fun. The museum down at park headquarters is spectacular. Once, a year ago, we even saw a puma—including Renata, my daughter here, yes, she saw it too. An experience to remember.

Estancia San Alonso was the logical site for the most dramatic act of rewilding: reintroducing jaguars.

That evening, while we eat a pasta dinner Tompkins has cooked, she mentions that she will fly off early next morning in the Husky, with her pilot, to look at an interesting place on the Chilean slopes of Cerro San Lorenzo, just south along the high Andean border, that might merit buying.

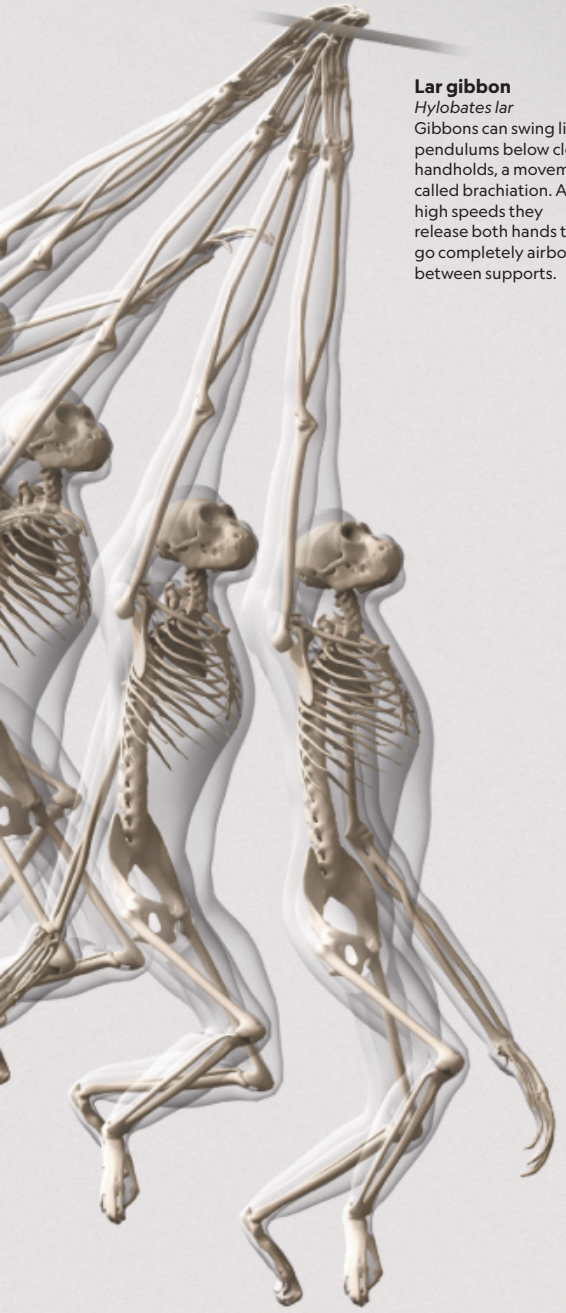
"When does it end, Kris?" I ask.

"It doesn't," she says. "Until I kick the bucket." □

David Quammen's most recent book is *The Tangled Tree: A Radical New History of Life*. Chilean photographer **Tomás Munita** focuses on social and environmental issues.

Land animals have developed countless solutions to a single challenge: how best to get from one place to another. Modes of travel vary depending on an animal's size and environment, with the goal of moving efficiently toward resources and away from danger.

BODIES IN MO



Lar gibbon
Hylobates lar
Gibbons can swing like pendulums below close handholds, a movement called brachiation. At high speeds they release both hands to go completely airborne between supports.

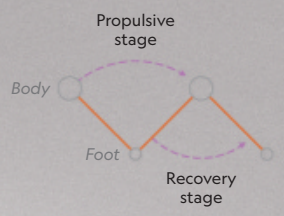
TION

BY **JASON TREAT, BRAD SCRIBER, AND PATRICIA HEALY**

ILLUSTRATIONS BY **BRYAN CHRISTIE DESIGN**

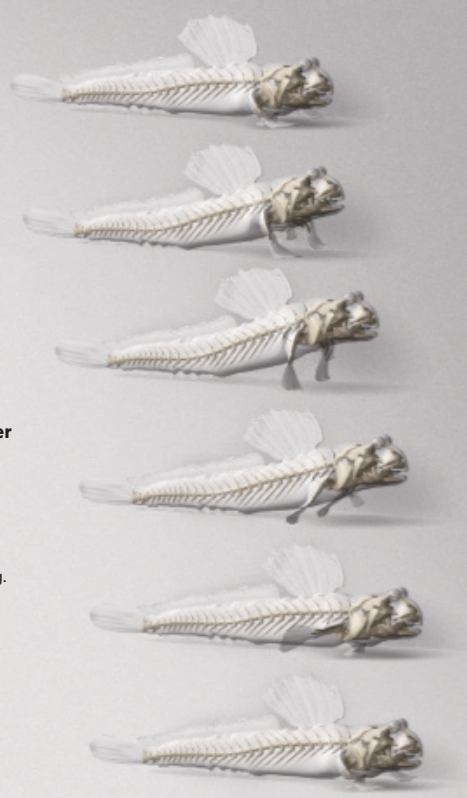
FUNDAMENTALS OF MOVEMENT

In a full stride, a land animal's limb propels the body forward, then resets to recover leverage for the next step. Animals change gaits by varying the order that limbs make contact with the ground, as well as the duration and frequency of those contacts.



FINS AND FEET

Some modern fish can move overland by pushing their bodies up with their fins and flopping forward. The limbs of tetrapods—four-legged vertebrates, including amphibians—evolved from the fins of ancestral fish species. Feet developed underwater, but the search for food and safety may have coaxed some early walkers onto dry ground. Natural selection drove arms, legs, feet, and hands to diversify and specialize.



Graceful mudskipper
Periophthalmus gracilis
Less refined than their name suggests, mudskippers can use their front fins on land in a lurching style of locomotion called crutching.

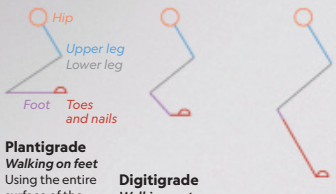
Tiger salamander
Ambystoma tigrinum
A salamander's life cycle transition—from aquatic larva to terrestrial adult with sprawled legs—reflects one way that walking evolved.

Zebra-tailed lizard
Callisaurus draconoides
All lizards bend their bodies from side to side, elongating their four-legged steps. But this type can extend its ankles and run on its toes, traveling 50 body lengths a second.

QUADRUPEDS

From skittering shrews to lumbering elephants, quadruped bodies are shaped by physics and physiology. Larger animals have more powerful muscles, but their skeletons have to support much greater weight. Smaller animals typically move more quickly but use energy less efficiently. Leg differences reflect certain trade-offs.

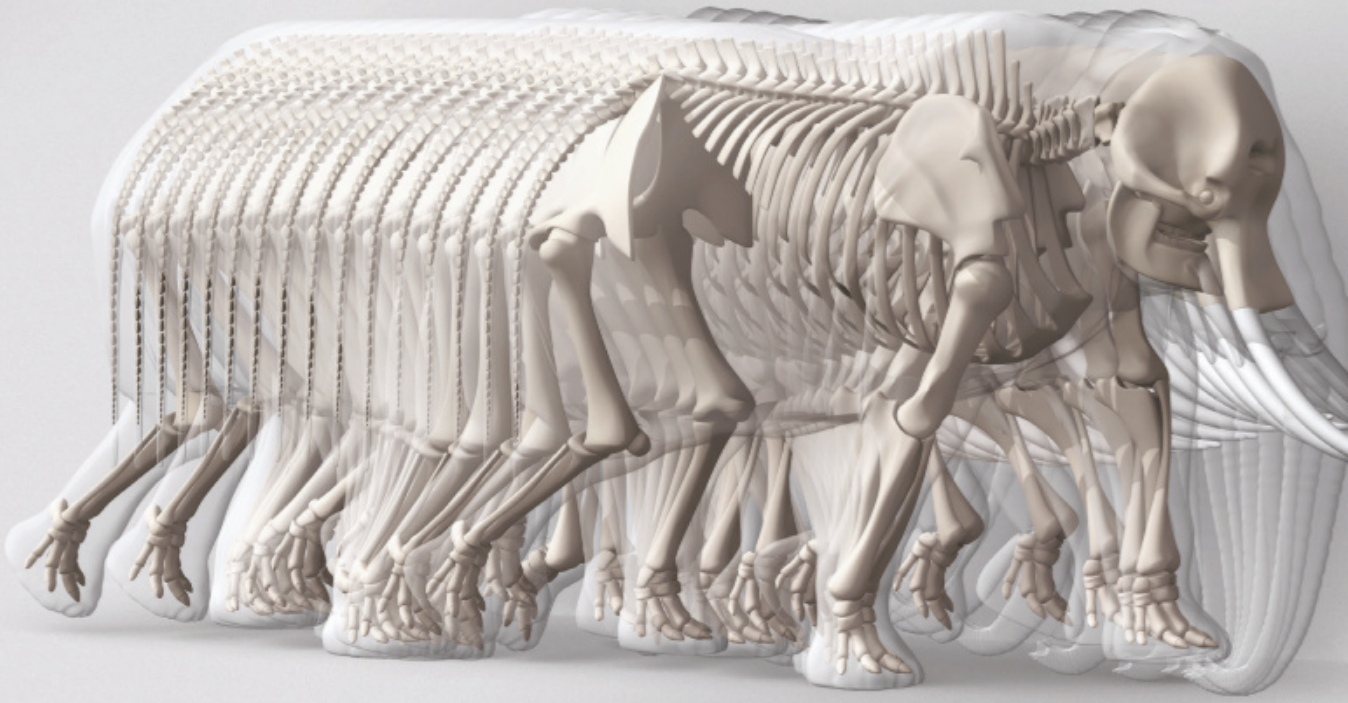
HIND LIMBS



Plantigrade
Walking on feet
Using the entire surface of the foot provides stability, but upper bones in flexed legs are subject to greater forces.

Digitigrade
Walking on toes
Many predators move on toe pads with their heels permanently raised, giving them power, speed, and stealth.

Unguligrade
Walking on nails
Hooves are specialized toenails on elongated feet. Ungulates' straighter legs can support larger loads.



Cheetah
Acinonyx jubatus
A flexible spine that arches and then extends gives cheetahs their extremely long stride. Their light, furry tails and sharp claws offer stability during turns.

18+

WHAT IS AVAXHOME?

AVAXHOME-

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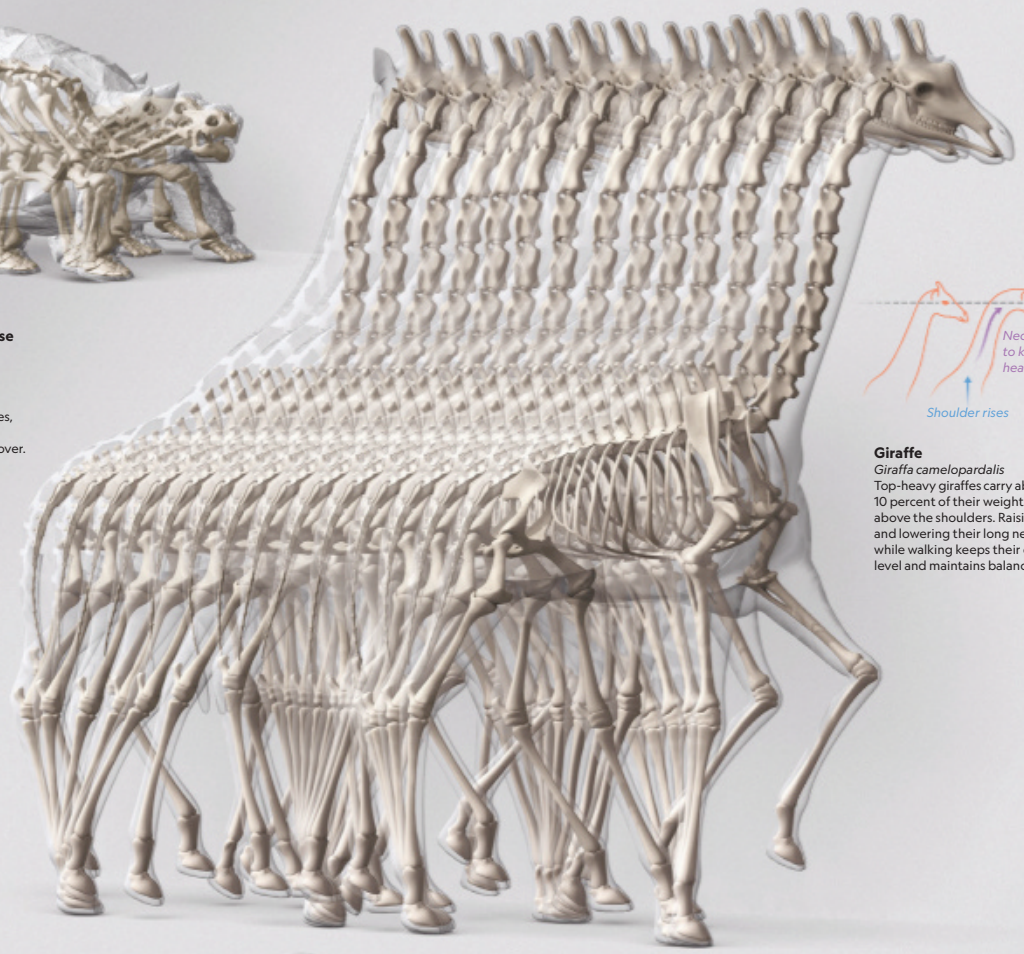
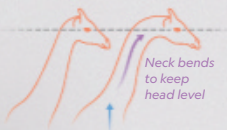
African spurred tortoise
Centrochelys sulcata
Plant-eaters with rigid defensive shells, tortoises favor stability over speed. They can climb steep slopes, and their well-spaced feet keep them from toppling over.

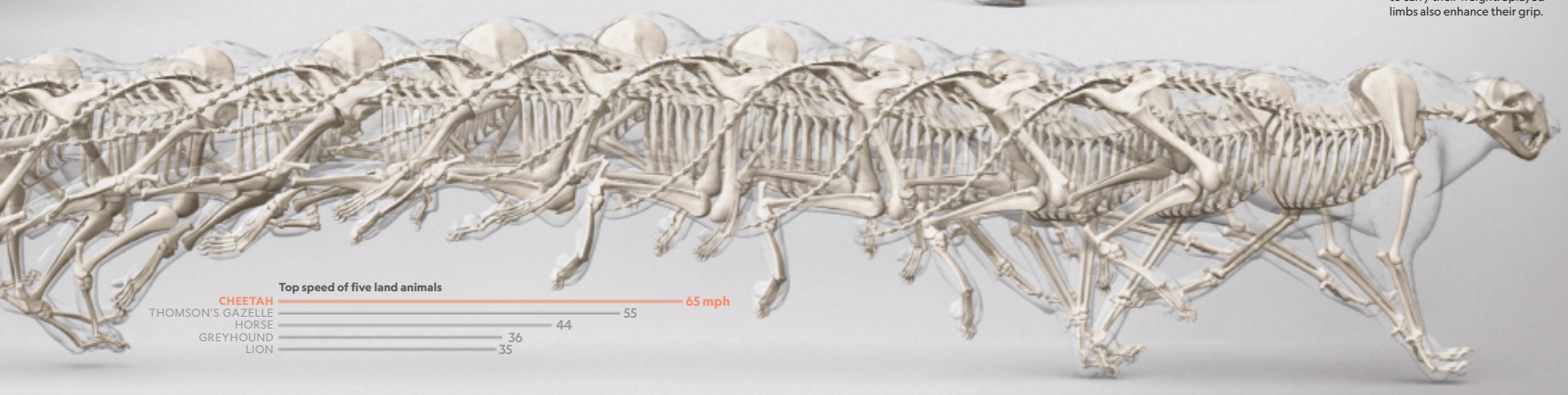
African elephant
Loxodonta africana
Titans on tiptoes, elephants can amble quickly but can't trot or gallop. A pad behind the toes lets their raised-heel, digitigrade bone structure work like humans' flat feet.





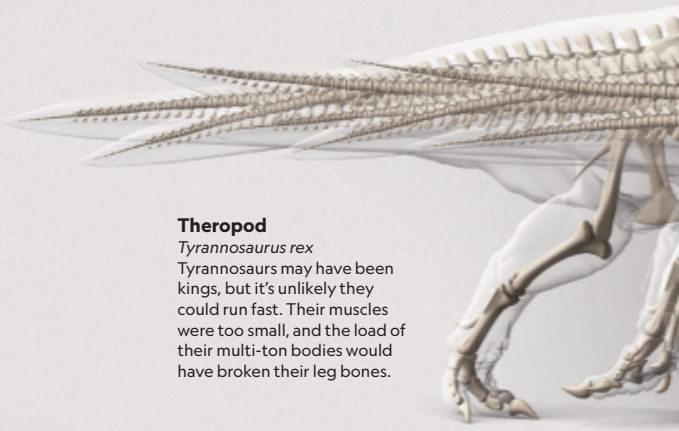
Giraffe
Giraffa camelopardalis
Top-heavy giraffes carry about 10 percent of their weight above the shoulders. Raising and lowering their long necks while walking keeps their eyes level and maintains balance.

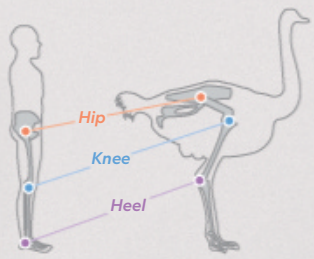
Eastern gray squirrel
Sciurus carolinensis
When climbing down, squirrels swivel their hind feet at the ankles so their toes point up and their claws are positioned to carry their weight. Splayed limbs also enhance their grip.

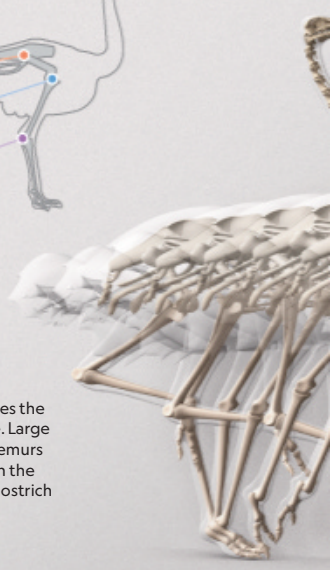


Human
Homo sapiens
More efficient when walking than when running, human legs function like inverted pendulums. Part of each step uses momentum and gravity to move the body forward.

Theropod
Tyrannosaurus rex
Tyrannosaurs may have been kings, but it's unlikely they could run fast. Their muscles were too small, and the load of their multi-ton bodies would have broken their leg bones.



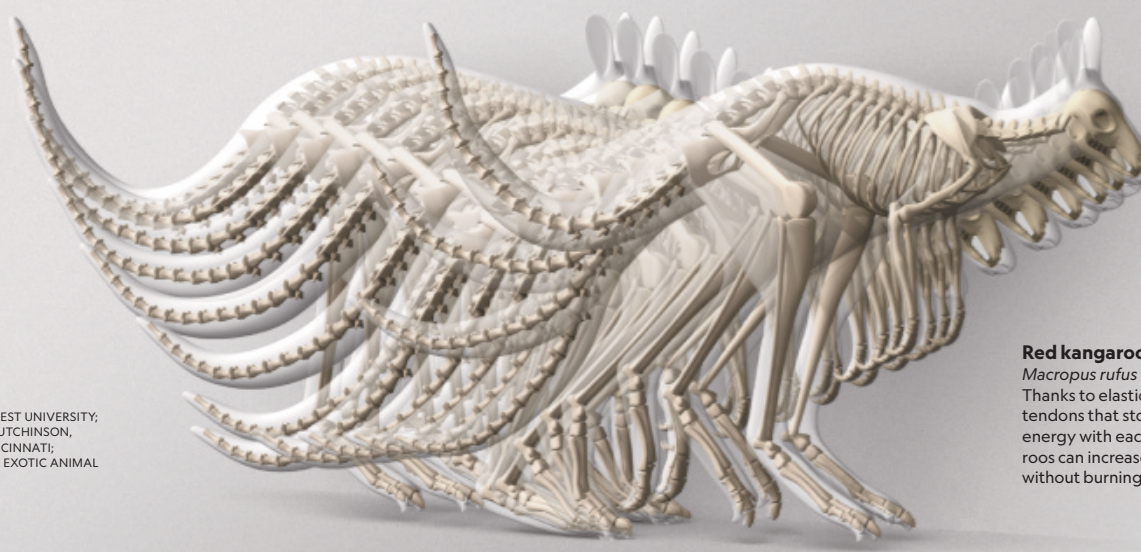




Ostrich
Struthio camelus
An ostrich's heel matches the height of a human knee. Large muscles around short femurs plus long, light bones in the rest of the leg help the ostrich take big, quick steps.

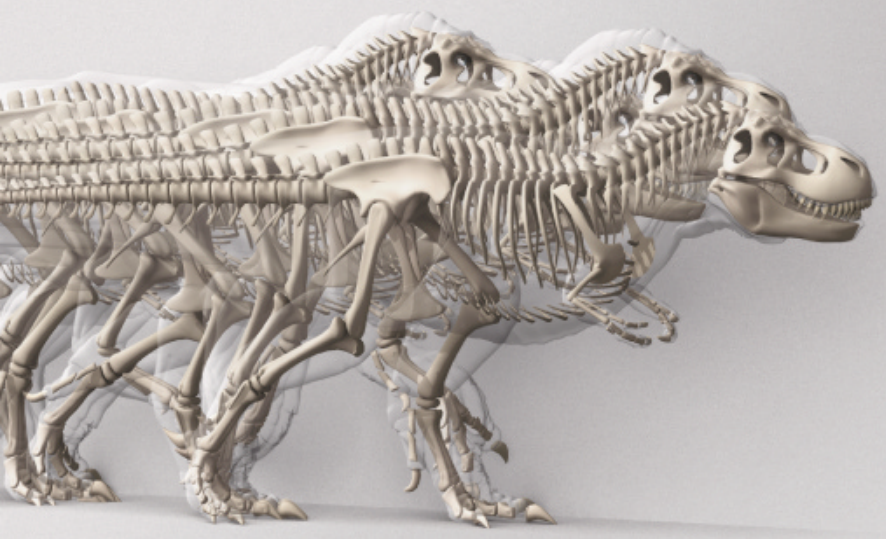
BIPEDALISM

Humans and birds use forelimbs for grasping or flying but rely on their two legs for walking. Other animals move bipedally only when needed. Kangaroos forage pentapedally—using all four legs and their tails—but hop with just their hind legs for speed.



Red kangaroo
Macropus rufus
Thanks to elastic tendons that sto energy with eac roos can increas without burning

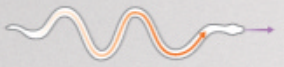
SOURCES: PARVEZ ALAM, UNIVERSITY OF EDINBURGH; MIRIAM A. ASHLEY-ROSS, WAKE FOREST UNIVERSITY; ANDREW BIEWENER, HARVARD UNIVERSITY; S. TONIA HSIEH, TEMPLE UNIVERSITY; JOHN HUTCHINSON, ROYAL VETERINARY COLLEGE, UNIVERSITY OF LONDON; BRUCE JAYNE, UNIVERSITY OF CINCINNATI; MELISSA MERRICK AND JOHN KOPROWSKI, UNIVERSITY OF ARIZONA; SCOTT STAHL, STAHL EXOTIC ANIMAL VETERINARY SERVICES; NAOMI WADA, YAMAGUCHI UNIVERSITY



NO LEGS

Snakes use muscles, skin, and a flexible body to propel themselves over a variety of surfaces. Some techniques use less friction and are better for loose, level terrain. Others use points of contact along the pliable body to push off of bumps on the ground, the sides of passages, or tree bark.

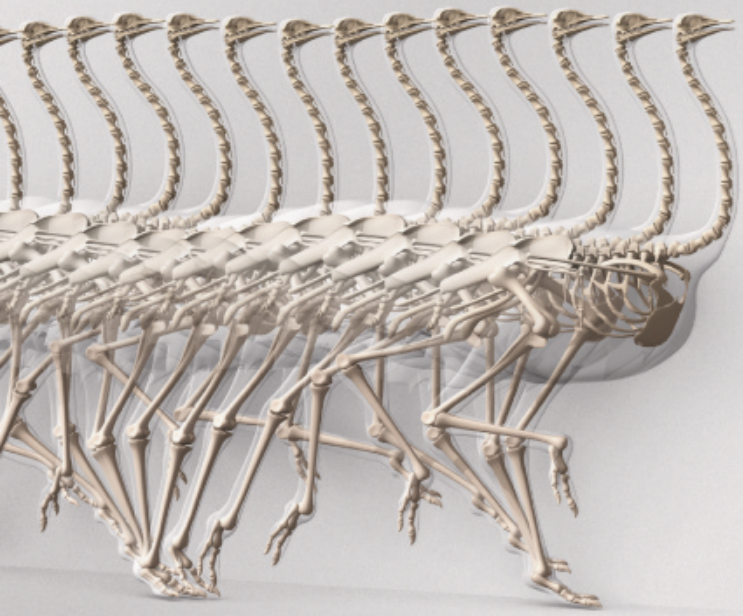
Sidewinding
On loose sand, the head lifts into place first. The rest follows in a whipping motion.



Serpentine
In the most common movement, the body follows the head along a single, wavy path.

Concertina
Parts of the snake bunch up, gaining leverage so other sections can extend forward.

Rectilinear
Muscles clench the underbelly scales to grip the ground and pull the snake in a straight line.

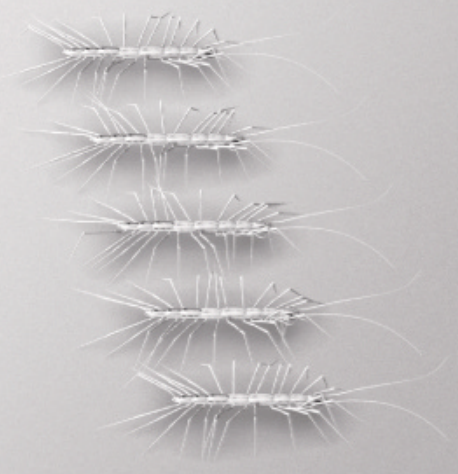


MANY LEGS

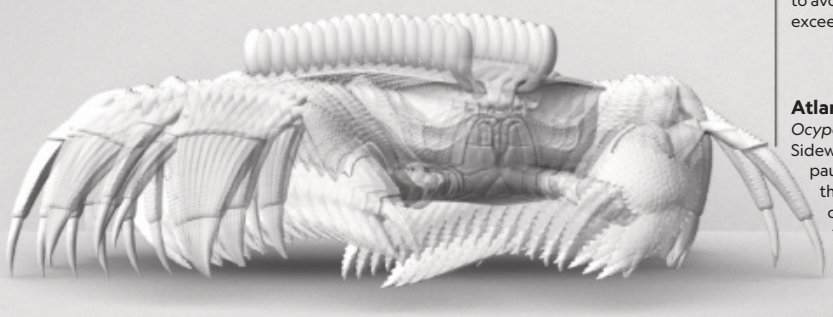
Most invertebrates spread their body weight across multiple legs, which lessens the load on each limb. Moving requires coordination or even varied leg lengths so they don't trip over their own feet.

Stable steppers
Creatures with legs to spare, such as ants or crabs, often use alternating gaits, with half their legs stepping while the rest stay grounded.

House centipede
Scutigera coleoptrata
Undulating steps begin with the rear legs, which are longer to avoid tangling. Each stride exceeds total body length.



Atlantic ghost crab
Ocypode quadrata
Sideways-running ghost crabs pause frequently while fleeing threats. This slows the buildup of lactate and allows them to travel farther before tiring.



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Italy's

IN **PUGLIA,** AND IN PASTORAL REGIONS AROUND THE WORLD, THE SEASONAL **MIGRATION** REMAINS A COMMUNITY **TRADITION.**

Timeless Trails

BY **ALEXIS MARIE ADAMS**

PHOTOGRAPHS BY **GIUSEPPE NUCCI**

E

EACH JUNE, Nunzio Marcelli gathers his flock of 1,300 sheep and leaves his home near the medieval village of Anversa degli Abruzzi in the Apennine Mountains of central Italy. Walking some 30 miles over three days, 65-year-old Marcelli, his shepherds, and a few guests curious about this region's traditional way of life herd the animals to an alpine meadow high above the Marcelli farm.

The route from the farm to the animals' summer pasture follows a *tratturo,* the Italian word for the paths carved into this land by more than 2,300 years of such migrations. After clattering through Anversa's cobblestone streets, the sheep and their herders scramble upward. They switchback through seas of wildflowers, old-growth beech and pine forests, and crumbling stone villages—including the ethereal hamlet of Castrovalva, population 12, which clings to a craggy limestone crown jutting into the sky. On the afternoon of the third day, they crest onto a 6,561-foot-high plateau below the still snowcapped Monte Greco.

Although less than a hundred miles from Rome, the plateau feels like a forgotten world. Bumblebees browse wild oregano and thyme. Golden eagles and falcons wing through the bright blue Apennine sky. Hundreds of species of herbs, grasses, and wildflowers grow in dizzying profusion. Mobile phones don't work here. This

Historic cowbells hang on a rail in San Marco in Lamis, before the Colantuono family and their herd depart on the *transumanza,* or transhumance, a twice-yearly pastoral migration. In a journey with roots in Neolithic times, the family leads a 112-mile, four-day cattle drive from Puglia to summer meadows in Molise. The bells help herders find stray animals and symbolize the family's ties to this agrarian tradition.

PREVIOUS PHOTO

A herd of 300 enters Castropignano, during the last day of the Colantuonos' passage.

is the kind of place you'd never want to leave.

But Marcelli has work to do back on the farm, which he also runs as an *agriturismo,* with farmstead rooms open to travelers. So, after a celebratory lunch consisting of traditional Abruzzese fare such as lamb stew or *pancotto,* a bread-and-vegetable soup, everyone returns by van to Anversa.

Everyone, that is, but the sheep that will remain here—on public land Marcelli leases from the district of Scanno near the border of the National Park of Abruzzo, Lazio and Molise—through summer and early fall, feasting on the meadows' lush forage. The shepherds stay too, with their Abruzzese mastiff guard dogs, to watch over and protect the flock from wolves, bears, and other predators.

Come November, Marcelli and his shepherds, and sometimes a few of the agriturismo's guests willing to brave the late autumn cold, reverse the journey to bring the livestock home. Every year the pattern endures.

This twice-yearly migration has a name—and, as of December 11, 2019, recognition from UNESCO as a vital element of human culture. Called transhumance, from the Latin *trans* for "across" and *humus* for "earth," the seasonal movement of people and their livestock to and from summer and winter grazing grounds has been practiced for thousands of years by pastoral cultures on every inhabited continent.

This wholly utilitarian and pragmatic task driven by necessity is now inscribed on UNESCO's List of Intangible Cultural Heritage

CLOCKWISE FROM TOP LEFT

In Monte Sant'Angelo a crowd gathers to watch a procession during the feast day of St. Michael the Archangel, the protector of shepherds. The Pugliese town lies along the network of *tratturi,* the trails long used in Italy for the transhumance.

Musicians play accordion, *zampogna di Panni* (an ancient bagpipe unique to the region), and *ciaramella* (a traditional oboe) at an annual bagpipe festival in the town of Scapoli, in Molise. The bagpipe is linked to the god Pan, venerated in ancient times by shepherds.

An Abruzzese sheepdog watches over his flock during the annual sheep fair held in Fonte Vetica.

It takes William Rhind, a Maori shearer from New Zealand, around 80 seconds to shear a sheep. For about three months every year, shearers travel from farm to farm in Italy for work, including at the Marcelli family's farm in Anversa degli Abruzzi.

On May 1, the Abruzzese town of Cocullo hosts the Festa dei Serpari. Women in local garb carry bread-filled baskets while *serpari,* or snake handlers, prepare to drape the statue of patron saint Domenico di Sora in serpentine coils. The popular event grew out of the transhumance and the snakes on its paths.

of Humanity, along with Byzantine chant, the reggae music of Jamaica, and Argentine tango. When representatives from Italy, Greece, and Austria submitted a bid in March 2018, requesting that transhumance be added to the UNESCO list, they cited it as "more than just a profession for its practitioners, but a way of life."

SHEEP AND GOATS were the first animals that humans domesticated as livestock, around 10,000 years ago. Evidence of seasonal herding reaches back nearly as far. The Hulailan Valley of the central Zagros Mountains in Iran was first settled by transhumant herders around 7050 B.C., according to radiocarbon dating from a 1963 excavation. Another excavation, in the Aude Valley of southern France, revealed evidence of the movement of goats and sheep beginning in that region in about 4500 B.C.

Transhumance takes place between upper and lower altitudes—and between upper and lower latitudes—and involves all manner of livestock. On the Tigray Highlands of Ethiopia, herders move cattle, sheep, and goats. In Bhutan and Nepal, the practice includes yaks, water buffalo, and cattle. Pig transhumance has been a feature of Bosnian pastoral life.

Some ranchers in the American West still practice transhumance. One livestock corridor, the Green River Drift in Wyoming, has been used for more than a century and is on the National Register of Historic Places. Each spring, cowboys trail herds of cattle along the "drift" from desert grazing allotments in western Wyoming to summer pasture high in the Bridger-Teton National Forest. The nearly 60-mile journey takes three weeks to complete.

In southern Greece, where my family and I have lived off and on since the mid-1970s, the twice-yearly flow of people and their animals was so ingrained in the way of life that, until the late 1990s, it carried a priest and a schoolteacher with it.

Once, friends and I followed one of our region's transhumance pathways *(monopatia* in Greek) from the seaside village of Kyparíssi to an isolated summer settlement in the mountains. We arrived in Babala after a steep, four-hour hike. Stone *kalivia*—primitive summer cottages used by shepherds—were scattered across a rocky meadow crisscrossed by drystone walls that once enclosed vineyards and gardens. For centuries Babala was the summer home for dozens of Kyparíssi herding families. Today just one family makes the transhumance.

We were there because we had heard that they also made *touloumotiri*—cheese that is traditionally aged in the cleaned and heavily salted skin of a goat. For two years I had been searching for authentic touloumotiri (most cheesemakers now age it in barrels), and I finally found it there, in Babala, at the homestead of Dimitris and Yianoula Hiotis.

Dimitris told us about the blue mold that forms between the cheese and the skin, which he kneads into the cheese. Yianoula scooped out a chunk and placed it on a communal plate. Hunks of wood-toasted bread in hand, we dug in. The cheese was deliciously pungent and peppery—it was the touloumotiri of my childhood, the touloumotiri of transhumance.

IN MANY PLACES around the world, cheesemaking is central to transhumance. In Nepal, herders use yak's milk to produce a traditional

ROSEMARY P. WARDLEY, NGM STAFF. SOURCE: LETIZIA BINDI, UNIVERSITY OF MOLISE

On the third day of the Colantuonos' transhumance, herders dry off at a camp in Ripalimosani after a storm. Their trek follows one of five remaining migratory routes in the region.

The Colantuonos' journey to and from summer and winter pastures is part of a tradition practiced by communities around the world. UNESCO recently recognized transhumance for its cultural significance.

WE HAVE **TRANSHUMANCE** TO THANK FOR YODELING AND THE ALPENHORN, AND COUNTLESS FOLK SONGS, POEMS, FEASTS, AND FESTIVALS.

cheese called *chhurpi,* as well as butter and ghee. Western Macedonia's *sarplaninski ovci kashkaval* is produced only in the summer and only when the sheep are grazing at altitudes of 3,280 and 4,920 feet (1,000 and 1,500 meters). Spain's Idiazabal cheese originally was made by shepherds in the Basque and Navarra regions, its smoky flavor a result of being aged near the fireplace in the shepherds' rustic stone huts.

In all of these cases, the cheesemakers count on access for their animals to wild pasture because its diverse forage imparts specific flavors to the milk the animals produce, which in turn affects the flavors of the cheeses. In the Alps, this milk is called *heumilch,* German for "hay milk," and contributes to the distinctive taste of Alpine cheeses such as *sura kees, graukäse,* and *Alpenkönig.*

About 75 miles southeast of the Marcelli family farm, fourth-generation cheesemaker and dairy farmer Carmelina Colantuono also practices transhumance, but on horseback, herding her family's 300 mostly Podolica cows more than 100 miles to and from winter pasture. Colantuono's award-winning *caciocavallo* cheese, fragrant with the wild grasses and herbs of Puglia and Molise, is served in restaurants from Rome to Manhattan.

Wherever it is practiced, transhumance has helped shape landscapes: Over millennia, shrines, churches, inns, and eventually villages materialized near the pathways. In Molise, the ancient town of Saepinum developed along one of Italy's main *tratturi.* The town is said to have been named for the Latin verb *saepire,* meaning "to fence in"—after its many walled sheep pens. On one of the town gates, an inscription dating back to A.D. 168 forbids the townspeople from harming the shepherds passing through on the tratturo.

In Greece, monopatia were the only means of connection between otherwise isolated mountain and coastal communities; along their routes, trade and even romance bloomed. In Voskina, a shepherd village north of Babala, a cheesemaker friend told me the story of her marriage nearly 60 years ago to a young man from a seaside village a day's walk from her family's home. The marriage was arranged by her father, who walked the pathways to find a suitable match for her. This practice, she told me, was commonplace then.

We have transhumance to thank for yodeling and the alpenhorn, and countless folk songs, poems, feasts, and festivals, all of which flourished in the wake of the herders. In Madrid each October, during the Fiesta de la Trashumancia, about 2,000 sheep are herded through the heart of the Spanish capital. When the shepherds and their flocks reach the city center, they gather on the elegant Plaza de Cibeles with its neoclassical sculptures and fountains. There, the shepherds pay the mayor, who presides over the spectacle, 50 *maravedís al millar*—the fee imposed in the year 1418 per thousand (millar) head of sheep.

Research has shown that from Spain to the Tyrol to the boreal pastures of Norway, the pathways of transhumance support biodiversity by linking grasslands and forests, often in regions fragmented by development and intensive agricultural cultivation. They also provide migration corridors for wildlife, as well as habitat for animals and plants. Proponents of including transhumance on the UNESCO list also suggest that the practice is more sustainable than intensive livestock farming.

A study of the "traditional ecological knowledge" of transhumant shepherds in Spain posits that such knowledge—of flora, fauna, and natural phenomena resulting from a culture having direct contact with an environment for generations—helps those people adapt to environmental change and be effective stewards of the land.

When he was a child, Marcelli says, he was told, "If you don't study, you'll have to graze the sheep." He embraced that notion. While he did study—economics and commerce at the Sapienza University of Rome—he wrote his dissertation on using sustainable

methods of sheep breeding to stimulate rural Abruzzo's economy.

In 1977, three years before completing his dissertation, he moved home and began raising sheep. Manuela Cozzi came with him, and together they started La Porta dei Parchi farm. Today Marcelli and Cozzi run the operation with their daughter, Viola, 34, and their son, Jacopo, 32. Driven by the same passion that inspired her parents, Viola, who studied painting and product design in Florence, is the farm's head cheesemaker and the chef for their agriturismo's restaurant, and she leads the regional sheep cooperative.

"In the past there were millions of sheep in Abruzzo," she says. "Now there are maybe 200,000. We raise sheep because we hope to inspire others to do the same. We make the *transumanza* because it is good for the health of the animals and it is good for this place. It is part of this mountain culture, and we don't want this culture to die."

Transhumance faces many challenges, from climate change, which can alter the forage, to shifting demographics and evolving land-use policies and patterns. Over time, some herding, or drove, roads have become motor roads. Others now intersect highways or rail lines. Pasture is turned into cropland. Young people leave the villages or have little interest in continuing their families' traditional livelihoods. Although the Italian tratturi are public property, Colantuono must apply for permits to cross highways and pass through villages and towns before leading her family's cattle to and from Puglia each year. For Marcelli the challenges include not only livestock predators but also politicians whose policymaking, he says, isn't farmer friendly.

Viola Marcelli is grateful for the UNESCO ruling. She hopes it will help make transhumance, and small-scale agriculture in general, more viable for her family and others.

"It's a hard job being a farmer," she says. But overcoming the challenges is worthwhile, she adds. "The sheep, the pasture, the milk, the cheese we make, the transumanza, these have been a part of Abruzzo and Italy for thousands of years. These are the lifeblood of this place. They're the soul of our people." ▯

Based in rural Montana and rural Greece, **Alexis Marie Adams** writes about food, culture, and travel. **Giuseppe Nucci** is globally recognized for his documentary projects.

Travel Wise: Transhumance

WHAT TO KNOW

Today transhumance is as much a movement as an agricultural practice. Organizations such as Le Vie dei Tratturi advocate for shepherds' rights and corridor protection, and provide information to travelers on events, museums, and exhibits with, in some cases, maps of trails and herding roads.

Guided hikes, mountain bike tours, and expeditions on horseback delve into the practice and history of transhumance. Most guided tours operate during the spring and fall, with guests helping shepherd the livestock. Not all transhumance pathways are open to the public; it's important to check before exploring.

FESTIVALS

Whether celebrating the safe return of the herd or advocating for shepherds' rights, transhumance festivals take place around the world. They often include traditional folk music, feasting, costumes, and dance—in addition to livestock parading by the hundreds, sometimes thousands, through the streets.

SOUTHERN ITALY
Tricarico Carnival
In the town of Tricarico, in the Basilicata region, a transhumance reenactment takes place each January 17, the feast day of St. Anthony the Abbot, the protector of animals.

MADRID, SPAIN
Fiesta de la Trashumancia
With its stunning architecture and elegant neoclassical fountain, Madrid's Plaza de Cibeles might be the last place you'd expect to hear the din of thousands of bleating sheep. That's exactly what you'll get during this annual festival, scheduled this year for October 18. The event started in 1994 as a protest to assert shepherds' rights to use Spain's ancient drove roads.

PETALUMA, CALIFORNIA
Transhumance Festival
This "celebration of grassland culture"—on May 16 this year—includes talks and exhibits about indigenous foodways, grazing, fire ecology, and land ethics.

BOISE, IDAHO
Jaialdi
Basque shepherds initially lured by the California gold rush were instrumental in establishing the West's transhumance routes and traditions. Idaho has the largest concentration of Basques in the U.S.; every five years the state's capital hosts one of the world's biggest Basque festivals. (In Euskara, the Basque language, *jaialdi* is the word for "festival.") During the six-day event, this year from July 28 to August 2, paella and chorizo rule.

INSTAGRAM

VINCENT J. MUSI

FROM OUR PHOTOGRAPHERS

WHO

Musi specializes in animal and science photography.

WHERE

Musi's studio in Sullivan, South Carolina, which Hodor visited from the Hallie Hill Animal Sanctuary for cats and dogs in Hollywood, South Carolina

WHAT

A Fujifilm GFX100 camera with a 32-64mm lens

For 25 years Musi has photographed the planet's most majestic wildlife for *National Geographic*. In 2018 he turned to more vulnerable animals: shelter dogs. His portrait series, The Underdogs, features older canines—some with missing limbs or sensory impairments—that are difficult to adopt out to homes. Musi thinks that Hodor, an 11-year-old hound dog (pictured above), would make a great companion, and if he could talk, would probably have great stories to tell.

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Slender-horned Gazelle *(Gazella leptoceros)*
Size: Body length, 101 - 116.5 cm (39.8 - 45.9 inches); shoulder height, 65 - 72 cm (25.6 - 28.3 inches) **Weight:** 14 - 27 kg (30.9 - 59.5 lbs) **Habitat:** Northern Sahara Desert **Surviving number:** Estimated at 300 - 600 adults

Photographed by Bruno D'Amicis

WILDLIFE AS CANON SEES IT

Sun. Sand. And very little else as far as the eye can see. The slender-horned gazelle was born to survive the pitiless desert. To optimize movement on the sand, it has longer hooves with a wider cleft than other antelope species. Able to travel great distances in search of vegetation, it derives most of the water it needs from dew and plant moisture. Overcoming the challenges of the desert is one thing, however, while surviving uncontrolled hunting and poaching is quite another. Today, only a few hundred remain.

As Canon sees it, images have the power to raise awareness of the threats facing endangered species and the natural environment, helping us make the world a better place.

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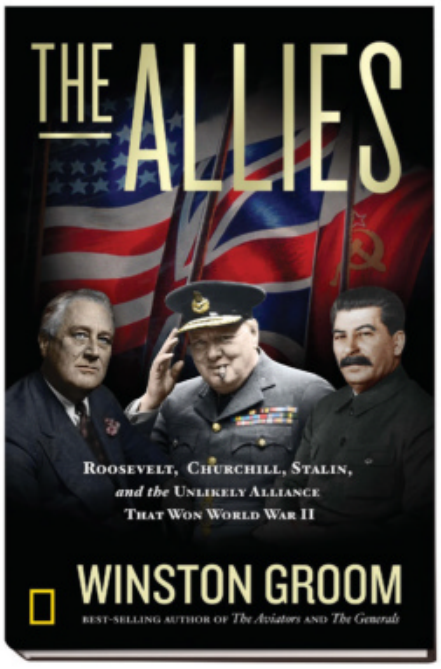
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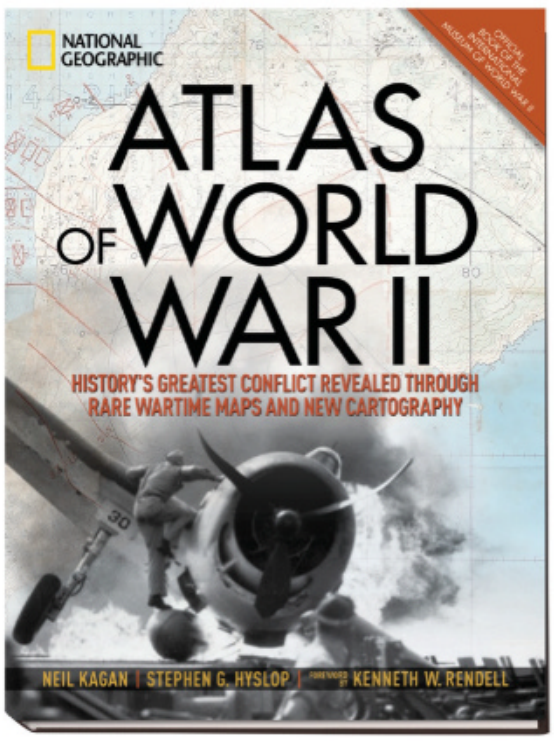
BEST-SELLING AUTHOR OF The Aviators AND The Generals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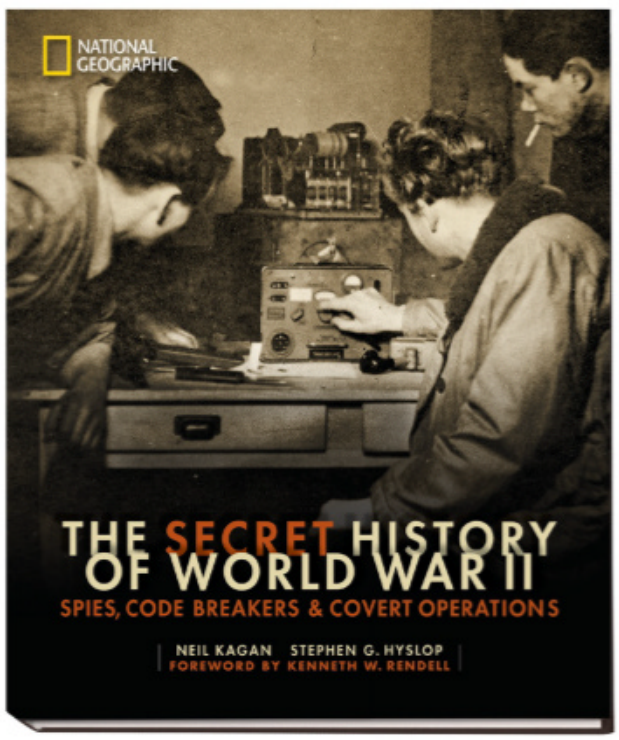
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